ANNALS

OF

The Entomological Society of America

VOLUME I, 1908

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CONTENTS OF VOLUME I.

Officers 3
Constitution 4
Membership 7
BRADLEY, J. C.—Proceedings of the Society—New York Meeting 21
Proceedings of the Society—Boston Meeting 22
Proceedings of the Society—Chicago Meeting 27
CROSBY—Notes on Chalcid Infesting Apple-seed 38
WHEELER, WM. M.—Polymorphism of Ants 59
OSBORN, HERBERT—The Habits of Insects as a Factor in Classification 70
SEVERIN, H. H. AND SEVERIN, H. C.—Anatomical and Histological Studies of the Female Reproductive Organs of the American-Saw fly, Cimbex Americana, Leach 87
FELT, E. P.—Some Problems in Nomenclature 102
HAMMAR, A. G.—On the Nervous System of the Larva of Corydalis cornuta L. 105
BRADLEY, J. C.—A Case of Gregarious Sleeping Habits among Aculeate Hymenoptera 127
DAVIS, J. J.—Notes on the Life History of the Leafy Dimorph of the Box-elder Aphid, Chaitophorus negundinis Thos. 130
HAMBLETON, J. C.—The Genus Corizus, with a Review of the North and Middle American Species 133
LYMAN, H. H.—The Entomological Society of America and Its Work 152
GIRAULT, A. A.—Further Biological Notes on the Colorado Potato Beetle, Leptinotarsa decemlineata (Say), including Observations on the Number of Generations and Length of the Period of Oviposition 155
GIRAULT, A. A.—A Monographic Catalogue of the Mymarid Genus Alaptus Haliday with Descriptions of Three New North American Forms and of Alaptus Iceryae Riley from Type Material 179
SEVERIN, H. H. AND SEVERIN, H. C.—The Internal Organs of Reproduction of the Male Saw-fly, Cimbex Americana Leach 196
SMITH, C. P.—A Preliminary Study of the Araneæ Theraphosae of California . 207
DAVIS, J. J.—Studies on Aphididae 251
RILEY, W. A.—Muscle Attachment of Insects 265
NEEDHAM, J. G.—Critical Notes on the Classification of the Corduliinae (Odonata) 273
HOWARD, L. O.—A Key to the Species of Prospaltella with Table of Hosts and Descriptions of Four New Species 281
HOOD, J. D.—Two New Species of Idolothrips 285
Index 291

264016

Yours very truly

Samuel H. Scudder

DR. SAMUEL HUBBARD SCUDDER,
Honorary Fellow, Entomological Society of America.

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ANNALS

OF

The Entomological Society of America

Volume I MARCH 1908 Number 1

INTRODUCTORY

This initial number of the Annals of the Entomological Society of America marks the beginning of an enterprise which it is hoped may become of the greatest value to entomological science in America. Coming as it does as a response to the demand evidenced by a membership of nearly 500 reached within a year from the organization of the society, there is every reason to predict for it a useful service to entomological students.

The scope of the Annals will be as broad as the interests of the Society which it represents but it may not be out of place to emphasize the point that papers dealing with morphologic, faunistic and biologic problems as well as taxonomy in its broadest sense will be especially welcome.

Entomology at the present time is too intimately blended with other branches of science to permit of any narrow limitation for its activities. This Journal can, it is believed, best serve the Society and the science of Entomology at large by furnishing a medium of publication to the varied lines of research concerning insect life and all that pertains thereto. It can serve the progress of biological science in general by stimulating research and discussion concerning those phases of insect life which bear upon the deeper problems of life as a whole. The wealth

264016

of this material is too familiar to most entomologists to need mention but it is only too evident that the opportunity afforded has been too little appreciated by biologists. With a large and enthusiastic body of working entomologists for its support, an unlimited field for original work in the branch of science it represents, and with a growing appreciation of the value of science in general culture, we may predict for the Annals an unlimited growth.

For the sake of a permanent record this number includes the minutes of the meetings already held, copy of the constitution and a list of members. Hereafter these matters doubtless can be condensed into much smaller space and the pages devoted almost entirely to the scientific proceedings of the Society and to original papers.

THE ENTOMOLOGICAL SOCIETY OF AMERICA.

OFFICERS FOR THE YEAR 1907.

(Elected December 28, 1906.)

President ..... J. H. COMSTOCK
First Vice President ..... JAMES FLETCHER
Second Vice President ..... HENRY SKINNER
Secretary-Treasurer ..... J. CHESTER BRADLEY

Additional Members of the Executive Committee.

W. M. WHEELER	J. B. SMITH,	C. J. S. BETHUNE,
HERBERT OSBORN,	F. M. WEBSTER,	C. W. JOHNSON.

OFFICERS FOR THE YEAR 1908.

(Elected December 31, 1907.)

President ..... WM. M. WHEELER
First Vice President ..... J. B. SMITH
Second Vice President ..... C. J. S. BETHUNE
Secretary-Treasurer ..... J. CHESTER BRADLEY

Additional members of the Executive Committee.

J. H. COMSTOCK,	J. G. NEEDHAM,	P. P. CALVERT,
HERBERT OSBORN,	F. M. WEBSTER,	V. L. KELLOGG.

CONSTITUTION

(Adopted December 28, 1906.)

ARTICLE I.

NAME.

SECTION 1. This organization shall be known as THE ENTOMOLOGICAL SOCIETY OF AMERICA.

ARTICLE II.

OBJECTS.

SECTION 1. It shall be the purpose of this society to promote the science of entomology in all its branches, to secure co-operation in all measures tending to that end, and to facilitate personal intercourse between entomologists.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The membership of this society shall consist of three classes—members, fellows, and honorary fellows.

SEC. 2. All persons interested in entomology shall be eligible to membership.

SEC. 3. Members who have made important contributions to the science of entomology may be elected fellows or honorary fellows of the society.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of this society shall be a President, two Vice-Presidents, and a Secretary-Treasurer. The duties of these officers shall be those usually pertaining to their respective offices.

SEC. 2. The business of the society not otherwise provided for shall be in the hands of an Executive Committee consisting of the officers named in Section 1, and of six additional members, who shall be elected from the Fellows by the Society. Four members of the committee shall constitute a quorum.

SEC. 3. The President shall represent the society upon the Council of the American Association for the Advancement of Science until such time as the society shall be qualified for representation by two councillors, in which case the second councillor shall be elected from the Fellows by the Executive Committee.

ARTICLE V.

ELECTIONS.

SECTION 1. Election of Members—Nominations for membership may be made by any two members, and election shall be by the Executive Committee.

SEC. 2. Election of Fellows—All nominations for fellows shall be signed by three or more fellows and each nomination shall be accompanied by the following information concerning the nominee: Name, address, occupation, branches of entomology engaged in, positions held involving entomological experience, entomological work done, and list of more important publications. Election shall be by ballot by the Executive Committee, a majority vote of the committee being necessary for election.

SEC. 3. Election of Officers—All officers shall be elected by ballot at the annual meeting for a term of one year, and shall be eligible for re-election. All officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from the list of Fellows. Provided: The first permanent officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from members who at the time of their election are Fellows of the American Association for the Advancement of Science.

SEC. 4. Election of Honorary Fellows—All nominations for Honorary Fellows shall be made in the manner prescribed for the nomination of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Election shall be by mail ballot of the Fellows of the society, a two-thirds vote of all the Fellows being required for election.

ARTICLE VI.

MEETINGS.

SECTION 1. An annual meeting shall be held in conjunction with the annual meeting of the American Association for the Advancement of Science, and at such time and place as the officers may elect.

Article VII.

Amendments.

Section 1. This constitution may be altered or amended at any annual meeting by a two-thirds vote of the members present, a copy of each amendment proposed having been presented at the previous annual meeting.

BY-LAWS.

1. The annual dues for members and Fellows shall be one dollar.

2. A majority of the members present at an annual meeting shall constitute a quorum for the transaction of business.

3. Notice of all meetings of the society shall be sent to all members at least one month in advance.

4. The Executive Committee shall provide a program for all meetings, including at the annual meeting a popular lecture and a technical entomological exhibit of materials and methods.

5. The time of the business session shall be published prior to the opening session of the annual meeting.

MEMBERSHIP OF THE SOCIETY.

Honorary Fellows.

(Elected August 21, 1907.)

Ashmead, Dr. William Harris, U. S. Nat. Mus., Washington, D. C.

Cresson, Ezra Townsend, Hedgleigh, Swarthmore, Pa.

Edwards, William Henry, Coalburg, West Virginia.

McCook, Rev. Dr. Henry Christopher, Brookcamp, Devon, Pa.

Scudder, Dr. Samuel Hubbard, 156 Brattle Street, Cambridge Mass.

Uhler, Dr. Philip Reese, 254 W. Hoffman Street, Baltimore, Md.

Ulke, Henry, 411 15th Street, N. W., Washington, D. C.

Fellows.

Aldrich, Prof. J. M., University of Idaho, Moscow, Idaho. Aug. 21, 1907.

Bethune, Rev. Dr. C. J. S., Guelph, Ontario, Canada. Dec. 28, 1906.

Beutenmuller, William, American Museum Natural History, New York City. Aug. 21, 1907.

Bruner, Prof. Lawrence, Lincoln, Neb. Dec. 29, 1907.

Calvert, Dr. P. P., Biological Hall, University of Pennsylvania, Philadelphia. Aug. 21, 1907.

Comstock, Prof. John Henry, Ithaca, N. Y. Dec. 28, 1906.

Coquillett, D. W., Bureau of Entomology, Washington, D. C. Aug. 21, 1907.

Dyar, Dr. Harrison Gray, National Museum, Washington, D. C. Aug. 21, 1907.

Emerton, James H., 194 Clarendon Street, Boston, Mass. Aug. 21, 1907.

Fall, Henry C., 191 N. Raymond Ave., Pasadena, Cal. Dec. 29, 1907.

FERNALD, PROF. CHARLES HENRY, Amherst, Mass. Aug. 21, 1907.
FLETCHER, DR. JAMES, Central Experiment Farm, Ottawa, Canada. Dec. 28, 1906.
FOLSOM, DR. J. W., University of Illinois, Urbana, Illinois. Dec. 29, 1907.
FORBES, DR. S. A., 1209 W. Springfield Avenue, Urbana, Ill. Aug. 21, 1907.
GILLETTE, PROF. C. P., Fort Collins, Col. Dec. 29, 1907.
HENSHAW, SAMUEL, 8 Fayerweather Street, Cambridge, Mass. Aug. 21, 1907.
HOLLAND, DR. W. J., Director of Carnegie Museum, Pittsburg, Pa. Dec. 29, 1907.
HOPKINS, DR. A. D., Washington, D. C. Aug. 21, 1907.
HOWARD, DR. L. O., Department of Agriculture, Washington, D. C. Aug. 21, 1907.
JOHNSON, CHARLES W., Boston Society Natural History, Boston, Mass. Dec. 28, 1906.
KELLOGG, PROF. V. L., Leland Stanford University, Cal. Aug. 21, 1907.
LYMAN, HENRY H., 384 St. Paul Street, Montreal, Quebec. Aug. 21, 1907.
MARLATT, C. L., Bureau of Entomology, Washington, D. C. Dec. 29, 1907.
NEEDHAM, DR. JAMES G., Ithaca, New York. Aug. 21, 1907.
OSBORN, PROF. HERBERT, Ohio State University, Columbus, Ohio. Dec. 28, 1906.
SAUNDERS, DR. WILLIAM, Director Dominion Experiment Farm, Ottawa, Canada. Aug. 21, 1907.
SCHWARZ, E. A., Department of Agriculture, Washington, D. C. Aug. 21, 1907.
SKINNER, DR. HENRY, Logan Square, Philadelphia, Pa. Dec. 28, 1906.
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SMITH, DR. JOHN B., Agricultural Experiment Station, New Brunswick, N. J. Dec. 28, 1906.
WEBSTER, F. M., U. S. Department of Agriculture, Washington, D. C. Dec. 28, 1906.
WHEELER, DR. WILLIAM MORTON, American Museum Natural History, New York City. Dec. 28, 1906.

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Charter members, unless otherwise indicated.

[1] Signifies that the member was elected Aug. 21, 1907.

[2] Signifies that a member was elected Dec. 29, 1907.

[3] Signifies that a member was elected Dec. 31, 1907.

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PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

MINUTES OF THE NEW YORK MEETING OF DECEMBER 28, 1906. AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK.

The annual address arranged for by the provisional officers was delivered by Prof. Wm. Morton Wheeler, of the American Museum of Natural History, New York, on *Polymorphism in Ants*, and was illustrated by an extensive and very beautiful series of lantern slides. [A quite full abstract of this address is published in this number of the ANNALS.]

The business meeting was called to order by Prof. J. H. Comstock, Chairman of the Committee on Organization, and an order of business was adopted.

Prof. Comstock was elected Chairman, and E. S. G. Titus, Secretary, of the Meeting.

The Chairman announced that 216 persons had signified their intention of becoming members of the Society. On motion of Dr. L. O. Howard the Secretary cast the ballot making these persons members of the society.

The Chairman announced that the Committee on Organization were ready to present the constitution for consideration of the members. It was voted to adopt the constitution section by section, as read. Mr. Needham was appointed temporary secretary. Mr. Titus then read the constitution.

Articles I and II adopted as read. Article III, Dr. Skinner proposed an amendment making a third class of members: honorary fellows.

On motion of Prof. H. E. Summers, final consideration of this article was deferred until after passing upon the remainder of the constitution and by-laws.

Articles IV, V, VI, VII and by-laws were adopted with the amendments read by the Secretary.

Consideration of Article III being resumed, Dr. Skinner proposed the following amendments to sections 1 and 3. Section 1 to read "three classes—members, fellows, and honorary fellows." Sec. 3 to read "fellows or honorary fellows of the society."

A motion was carried to reconsider Article V.

Dr. Howard then presented an amendment as follows: "Sec. 4. Election of Honorary Fellows: All nominations for Honorary Fellows shall be made in the manner prescribed for the nominations of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Elections shall be by a mail ballot of the Fellows of the Society, a two-thirds vote of all the Fellows being required for election."

Article V adopted as amended.

The amendment was then adopted.

The constitution and by-laws, as a whole, were then unanimously adopted.

The society then proceeded to the election of officers.

The following officers were elected: President, J. H. Comstock; First Vice President, James Fletcher, Second Vice President, Henry Skinner; Secretary-Treasurer, J. Chester Bradley; the Secretary by vote of the Society casting the ballots for each of them.

The following names were nominated for additional members of the Executive Committee: Wm. M. Wheeler, F. M. Webster, Chas. W. Johnson, J. G. Needham, H. G. Dyar, G. P. Gillette, J. B. Smith, C. J. S. Bethune and Herbert Osborn.

The ballot resulted in the election of Messrs. Wheeler, Smith, Bethune, Osborn, Webster, and Johnson.

The Society then adjourned.

E. G. S. Titus, *Secretary.*

Minutes of the Boston Meeting.

The second meeting of the Entomological Society of America was held in the rooms of the Boston Society of Natural History on the evening of August 22, 1907. The following members were in attendance:

Prof. John Barlow, Kingston, R. I.
Rev. Prof. C. J. S. Bethune, Guelph, Ont.
Mr. William Beutenmuller, New York City.
Mr. C. V. Blackburn, Stoneham, Mass.
Mr. J. Chester Bradley, Berkeley, Cal.
Mr. A. F. Burgess, Boston, Mass.

Mr. Erich Daecke, Philadelphia.
Mr. N. S. Easton, Fall River, Mass.
Mr. J. H. Emerton, Boston, Mass.
Mr. F. P. Engelhardt, Brooklyn, N. Y.
Prof. C. H. Fernald, Amherst, Mass.
Prof. H. T. Fernald, Amherst, Mass.
Mr. W. L. W. Fields, Boston, Mass.
Mr. C. A. Frost, South Framingham, Mass.
Mr. F. Haimbach, Philadelphia, Pa.
Dr. Thomas J. Headlee, Durham, N. H.
Mr. E. F. Hitchings, Waterville, Me.
Dr. W. J. Holland, Pittsburg, Pa.
Mr. C. W. Johnson, Boston, Mass.
Prof. Vernon L. Kellogg, Stanford University, Cal.
Prof. Trevor Kincaid, Seattle, Wash.
Mr. F. E. Lutz, Cold Spring Harbor, N. Y.
Mr. H. H. Lyman, Montreal, Canada.
Mr. B. P. Mann, Washington, D. C.
Mr. C. L. Marlatt, Washington, D. C.
Mr. A. P. Morse, Wellesley, Mass.
Mr. H. H. Newcomb, Boston, Mass.
Prof. Herbert Osborn, Columbus, Ohio.
Prof. R. C. Osburn, New York City.
Miss Edith M. Patch, Orono, Me.
Dr. H. M. Russell, Winchendon, Mass.
Prof. E. D. Sanderson, Durham, N. H.
Dr. Henry Skinner, Philadelphia.
Prof. J. B. Smith, New Brunswick, N. J.
Mr. F. M. Webster, Washington, D. C.
Dr. Wm. Morton Wheeler, New York City.

In addition the following visitors were present:

Dr. G. Horvath, Budapest.
Prof. N. J. Kusnezov, St. Petersburg, Russia.
Prof. G. A. Severin, Bruxelles.
Dr. R. Heymons, Berlin.
Prof. and Mrs. T. D. A. Cockerell, Boulder, Colorado.
Mr. E. C. Cotton, Knoxville, Tenn.
Mr. W. F. Fiske, Washington, D. C.
Mr. J. Arthur Harris, St. Louis, Mo.
Mr. G. V. Pindar, New York City.
Mr. L. R. Reynolds, Boston, Mass.
Mr. A. C. Sampson, Sharon, Mass.
Mr. L. W. Swett, Bedford, Mass.
Mr. A. G. Weeks, Boston, Mass.
Mr. R. H. Wolcott, Lincoln, Neb.
Mr. Chas. Zeleny, Bloomington, Indiana.

In the absence of the President and First Vice President, the Second Vice President, Dr. Henry Skinner, presided. He opened the meeting with words of welcome to the foreign and other guests who were present, many as delegates to the Seventh International Congress of Zoology. Like all new movements this Society had opposition in the inception and there were those who did not see grounds for utility in its existence. Only by trying it can we fairly tell the results. If there were not a demand for such an organization, persons would not be so quick to join, for we already have over 400 members. In the opinion of the speaker, there are a few essential things which such a society should do; for one, to keep amateurs in touch with a central body. Now this very object would be thwarted were the Society to consist, as some have advocated, of delegates from local Societies, because by far the majority of entomologists are not in territory covered by any local society and would be unrepresented. In fact the societies are so few and gathered into such small territory as to be by no means representative. Another great object of such a society is to build up and foster local societies in unoccupied territory. Everyone is familiar with the growth of entomology in the present day. Many of us know the struggles of the older entomologists, and the discredit formerly cast upon their study. As an example of the present day ever-growing interest, the "News" might be mentioned, to refer to a personal subject, which every year has had to be printed in increasing numbers, and already the edition for 1907 is exhausted. The Society was only a natural incident to this increasing growth of entomology, and the speaker is a firm believer in its utility and wishes it a long life and great prosperity.

The Secretary then announced that the following persons had been duly elected Honorary Fellows of the Entomological Society of America:

Ezra Townsend Cresson, Samuel Hubbard Scudder,
Philip Reese Uhler, Henry Ulke,
William Henry Edwards, Henry Christopher McCook,
William Harris Ashmead.

The Secretary further announced that the following sixteen persons had been duly elected to Fellowship in the Entomological Society of America.

John Merton Aldrich,	Andrew Delmar Hopkins,
William Beutenmuller,	Leland Ossian Howard,
Philip Powell Calvert,	Vernon Lyman Kellogg,
Daniel William Coquillet,	William Saunders,
Harrison Gray Dyar,	Eugene Amandus Schwartz,
Charles Henry Fernald,	James George Needham,
Stephen Alfred Forbes,	Henry H. Lyman,
Samuel Henshaw,	James H. Emerton.

Prof. Osborn stated that it was the sense of the Executive Committee by its Committee on Publication that no attempt should be made at the publication of a journal that would occupy the field of any existing serial, and that it does not appear feasible to adopt any of the existing journals as the organ of the Society. It seemed to be the sense of the Committee that a dignified publication might be undertaken in the nature of a series of Annals or Memoirs, but that this should not be done until there was no question as to the permanency of the form in which it be started.

On invitation of the President, Dr. Horvath, Dr. Heymons and Prof. Severin, and later on the invitation of Dr. Holland, Prof. Kusnezov, responded each in turn with a brief address of greeting to the Society.

The Chair remarked that this was sacred entomologic ground, hallowed by the work of Drs. Harris and Scudder. Dr. Scudder's very old friend, Dr. J. G. Holland had been asked to bear him the greetings of the Society, and they now awaited with interest his response from Dr. Holland.

"No more grateful task Mr. President," said Dr. Holland, "could have been imposed upon me than to carry to Dr. Scudder the salutations of the Entomologcial Society of America. This afternoon I made my way to Cambridge, afraid that I might not be permitted to see him, because of the tidings that reached me of his greatly failing health, standing almost as he was within the eternal shadows. What was my satisfaction to be met at the door by his sister, who said he would be very glad indeed to see me. There I found him perfectly helpless in body but perfectly clear in mind. When I told him that I carried to him not only my own greetings, but those of the delegates to the Zoological

Congress and the Entomological Society of America, he replied, 'This is delicious.' He asked me to thank the Society from the fullness of his heart for having remembered an old man, now almost a shadow of his former self."

Dr. Bethune expressed the thanks of the Society to their entertainers in Boston and especially the Cambridge Entomological Club.

Dr. Smith offered a resolution which was heartily concurred in, that the thanks of this Society be expressed to Mr. Kirkland for the wonderful opportunity offered them for observing the experiments being carried on against the gypsy and brown tail moths, etc., at Saugus.

There being no further business the reading of papers was entered upon.

Papers were read as follows:

Dr. J. B. Smith, "Some Unrecognized Sexual Characters of Noctuidae," illustrated by lantern slides. The males of many Noctuids have characteristic tufts and hair pencils on the legs, and these reach their extreme development in the Deltoid series. Many other Noctuidae have hair pencils, brushes and scale tufts concealed in abdominal cavities, and of these little or nothing has been known heretofore. A few of the principal forms were shown on the slides. [Published Trans. Am. Ent. Soc.]

J. Chester Bradley, "A Case of Gregarious Sleeping Habits among Aculeate Hymenoptera." In the San Joaquin Valley this Summer, wasps had been noticed sleeping in bunches. Eight species were represented in considerable numbers, each species always grouped separately.

F. M. Webster, "Parasitism of Toxoptera." Illustrated by drawings to show the various positions assumed by the larva of Lysiphlebus in parasitizing Toxoptera, and causing the latter to assume the characteristic rotund form of parasitized individuals.

Discussion by Drs. Smith and Horvath.

J. Chester Bradley, "The Evolution of the Wings of Evaniidæ." Illustrated by charts. The wings of Evaniidæ portray in a remarkable manner the progress of evolution. From a relatively complex venation we find gradual steps through various degrees of atrophy resulting finally in the almost complete loss of venation. The group probably biphylletic.

Discussion by Dr. Holland and Prof. Kellogg..

W. L. Devereaux, "Slight Climate and Cicindela Faunal Change and extinction." In the absence of the author read by title only.

C. Abbott Davis, "Modern Methods of Mounting Insects." In the absence of the author read by title.

The meeting then adjourned to a smoker at which the Society and its visitors were the guests of the Cambridge Entomological Club, and had a most enjoyable time.

J. CHESTER BRADLEY, *Secretary-Treasurer.*

MINUTES OF THE THIRD MEETING.

The third meeting of the Entomological Society of America was held in the Zoological Building of the University of Chicago, December 30-31, 1907, in affiliation with the American Association for the Advancement of Science and allied societies.

The meeting was called to order by the First Vice President, Dr. Fletcher, at ten o'clock on Monday, December 30, 1907, and immediately adjourned until after the conclusion of the general session of the American Association for the Advancement of Science.

At eleven o'clock the meeting was again called to order, Dr. Fletcher in the chair.

Among those present during the sessions were: C. C. Adams, W. Barnes, C. E. Bartholomew, J. W. Folsom, G. M. Bentley, C. Betten, F. C. Bishop, D. Bodine, J. C. Bradley, W. E. Britton, C. T. Brues, L. Bruner, A. F. Burgess, H. E. Burke, J. H. Cook, M. T. Cook, C. R. Crosby, J. J. Davis, J. H. Emerton, E. P. Felt, H. T. Fernald, J. Fletcher, S. A. Forbes, W. J. Gerhard, J. E. Guthrie, J. L. Hancock, C. A. Hart, T. J. Headlee, W. E. Hinds, J. D. Hood, L. O. Howard, W. D. Hunter, F. Johnson, A. Kwiat, F. E. Lutz, H. H. Lyman, W. S. Marshall, D. Moulton, W. A. Nason, J. G. Needham, H. Osborn, E. M. Patch, J. L. Phillips, A. L. Quaintance, W. A. Riley, A. G. Ruggles, E. D. Sanderson, F. Sherman, Jr., J. B. Smith, R. I. Smith, H. E. Summers, T. B. Symons, W. L. Tower, R. A. Vickery, L. B. Walton, F. L. Washburn, H. E. Weed, H. F. Wickham, C. F. C. Riley, S. W. Williston; James Zetek, B. H. Guilbeau, J. F. Abbott, G. E. Sanders, G. D. Shafer, A. G. Hammar, A. B. Wolcott, E. L. Worsham, W. Newell, J. C. Hambleton, George G. Ainslie, G. P. Weld, J. E. Guthrie, and others.

The meeting proceeded directly to the reading and discussion of papers.

Notes on the Geographical Affinities of the Coleoptera of the Isle Royale, Lake Superior. (An outline of the relations of the Isle Royale beetle fauna to that of northern North America. General remarks on the major faunal centers based on beetles.) C. C. ADAMS.

Dr. Smith asked if there was not a large Carabid element present as Mr. Schwarz had found a very large proportion of these and of Staphylinidæ along the shores of Lake Michigan, and from the way Mr. Adams said the fauna had been derived one would expect the same on the Isle Royale. Mr. Adams said that that was the case. Dr. Fletcher asked if Mr. Adams had applied names to his areas. Mr. Adams had not, but he did not accept the zonal divisions of Merriam, since they did not hold for beetles.

Some Problems in Nomenclature. (A brief discussion of the validity of names, particularly those bestowed on Insect galls and larvæ). DR. E. P. FELT.

Prof. Hart asked what should be done with galls from which the adult insects were unknown. Dr. Felt would give them tentative names. Dr. Needham said that names of galls were of a different sort from those bestowed upon plants and animals and should not enter our zoological systems. Mr. Bradley added that English names, if used for galls, would avoid the confusion that the introduction of Latin names causes. He objected to even the tentative use of binomials.

Stereoscopic Photography applied to Entomological Subjects. PROF. F. L. WASHBURN.

Discussion by Messrs. Hinds and Summers. Mr. Bradley mentioned a very simple device which Mr. Crosby and he had used in obtaining good stereoscopic effects in photographing insects. It consisted of an ordinary camera having a brass diaphragm that could be reversed, and the aperture made eccentric. One exposure was made with the aperture on one side, and another with the aperture on the opposite side, the result giving an excellent stereoscopic effect.

Life history and habits of the Dimorph of Chaitophorus negundinis. Thos. (Previous knowledge of the dimorph. Comparison with a similar dimorph in Europe. Life history; appearance in summer. Part played in the survival of the species, etc.) J. J. DAVIS.

Discussion by Dr. Headlee and Dr. Fletcher.

Is Mutation a factor in the production of Vestigial Wings among Insects? (A summary of some observations among insects belonging to various groups, where the evolution of wingless or subapterous species can be traced within a group). C. T. BRUES. (To be published in Jour. N. Y. Ent. Soc.)

Mr. Hinds asked if Mr. Brues had paid attention to the winged condition in Thysanoptera. There one finds dimorphism due to season. There is no relation between the short winged and entirely apterous forms, but the same species will show short and long winged individuals. The paper was further discussed by Messrs. Smith, Bruner and Cook.

The meeting then adjourned until 1:30.

The afternoon session was opened by the reading of a paper by Dr. W. A. RILEY, entitled, *External Wing Buds in the Larva of Holometabolous Insects*. (A brief discussion of the general subject and recorded insects, and a report of an unrecorded instance.) (Published Entomological News, March, 1908.)

Dr. Needham said that he had never found any trace of external wings in the Larva of Diptera of Neuroptera that he had examined.

Notes on the Nervous System of the Cordyalis larva. A. G. HAMMAR.

Dr. Riley remarked that such work showed the need for careful studies of the nervous system of insects. He suggested that by tracing out the proper nerve Mr. Hammar might be able to locate the salivary gland, which no one had yet succeeded in doing. Dr. Smith asked Mr. Hammar for his technique. Fresh material was used hardened in Gilson's fluid and stained in picric acid. The incision is made on the dorsal side, and the dissection made under water, the larva being pinned to cork.

In the absence of the author, a paper by Dr. A. Petrunkevitch entitled, "*The Sense of Sight in Spiders*," was read by title only. (To be published in Journal Exp. Zool.)

Dr. Riley moved that nominations for President and First and Second Vice President, Secretary-Treasurer and the six additional members of the Executive Committee be by ballot, to be signed and handed in to the Secretary before 11 A. M., Tuesday, and that from the names so placed in nomination, the four leading each list be finally balloted upon, except that in the case of the Executive Committee, the first twelve be considered.

Seconded and after discussion carried.

The meeting then adjourned until after the conclusion of the address by Vice President Conklin before Section F., of the American Association for the Advancement of Science.

Upon reconvening, Mr. C. R. Crosby read a paper entitled, "*Notes on a Chalcid infesting an Apple-seed.*"

Prof. Bruner said that the species certainly was of much importance from a horticultural standpoint. Dr. Smith said he thought they might have been imported. Mr. Crosby said he had found them generally distributed over the state of New York. Dr. Howard felt certain that they had been imported. The discovery that Syntomaspis is phytophagous is one," he said, "of very great interest." Some time ago Mr. Banks had called the speaker's attention to the work of Motschulsky referred to by Mr. Crosby, and later on visiting Crimea he had seen Motschulsky's specimens. An assistant in the U. S. Bureau of Entomology has found what are probably the larvæ of this species in the seeds of an imported Russian haw. Dr. Fletcher said that in the past many apple seeds had been imported from Russia, and that he thought the insects might have entered in that way.

Dr. J. G. Needham read a paper entitled, "*The New Biological Field Station at Cornell University.*"

"*The mouth parts and phylogeny of the Siricoidea.*" J. Chester Bradley. Discussion by Dr. Smith and Dr. Riley.

"*Is Vespa borealis an Inquiline?*" (An account of finding males and females of Vespa borealis living together apparently on friendly terms.) Dr. James Fletcher.

Discussion by Mr. Brues and Dr. Smith. Dr. Fernald said that no worker of borealis had been described, and that two European species of Vespa were known to have a similar habit.

"*On certain Structural Characters of the genus Catocala.*" W. Beutenmuller. Read by title.

"*The Entomological Society of America and its work.*" H. H. Lyman.

"*The Habits of the Crane-fly Dicranomyia defuncta* O. S." Dr. J. G. Needham.

"*The Life history of a Bee fly, Spogostylum anale.* Say." (The larvæ parasitic on the larvæ of a tiger beetle, Cicindela scutellaris. Say. Eggs laid in July or August; larvæ on the last larval stage of the host in Spring; when host makes its pupal cell

and the internal parts become semi-fluid, the parasite moults and grows very rapidly completely destroying the host, (July). The pupa digs toward the surface by wriggling movements of the body, and the adult emerges when the surface is reached). V. E. SHELFORD. Read by title.

"*Circumfili in the Cecidomyiidæ.*" (A discussion of the morphology and taxonomic value of these organs). DR. E. P. FELT.

Dr. Riley thought that Dr. Felt's second explanation was correct,—that the circumfili are modified hairs.

"*Ancestral Ephemeridæ from the American Permian formation.*" (A group of true Ephemeridæ obtained from the Permian of Kansas. The earliest known true Ephemerids, and with the exception of a few Russian specimens, all that are known from the Permian. They present a distinct early stage in the evolution of the Ephemerid line). DR. E. H. SELLARDS. Title only.

Mr. Kwiat described the collecting grounds around Chicago.

Mr. J. H. Cook read a paper on the habits of the larvæ of Lycæna.

The meeting then adjourned until 11 o'clock on the following day.

At eight P. M. the annual address before the Society was given in the botanical lecture room of the University by Prof. Herbert Osborn, entitled, "The Habits of Insects as a Factor in Classification."

Afterwards the Society and their guests were entertained by the Entomological Section of the Chicago Academy of Science at a very enjoyable smoker.

BUSINESS MEETING.

On Tuesday, Dec. 31, at 11 A. M., the annual business meeting was held, Dr. Fletcher in the chair.

The Secretary read the minutes of the last annual meeting, also of the special meeting held in Boston in August. These were adopted as read.

The Secretary read a report from the Executive Committee embracing statement of accounts, the election of members and Fellows at the last meeting of the Committee, and a series of resolutions on publication adopted by the Committee from the report of their committee on publication.

These items were as follows:

Financial Statement, December 31, 1907.

EXPENDITURES.

Stamps	$ 64.77
Committee on Organization	43.08
Telegram	.27
Rubber stamp, etc	4.15
Printing	128.65
Clerks	18.30
Stationery	5.70
Expressage	5.75
Total	$270.67
	129.38
Total	$400.05

RECEIPTS.

Fees for 1907	$382.90
Fees for 1908	7.00
Fees due upon election	5.00
Miscellaneous	5.15
Total	$400.05

LIABILITIES.

Fees for 1908 of 7 members	$ 7.00
Fees due upon election of 5 persons	5.00
Total liabilities	$ 12.00

ASSETS (CASH.)

Refund on expressage	$ 3.00
Dues for 1907 of 39 members	39.00
Balance from one member	.10
Total assets	42.10
Liabilities	12.00
Balance	$ 30.10
Cash on hand	129.38
Total Resources	$159.48

Accounts examined and found correct.

[Signed.] H. OSBORN,
J. B. SMITH.

ELECTION OF THE FOLLOWING TO MEMBERSHIP.

G. E. Sanders, Urbana, Ill.; G. D. Shafer, Ithaca, N. Y.; J. A. Nelson, Ithaca, N. Y.; A. G. Hammar, Ithaca, N. Y.; Wm. H. Blatchley, Indianapolis, Ind.; A. B. Wolcott, Chicago, Ill.; E. L. Worsham, Atlanta, Ga.; R. W. Harned, Agricultural College, Miss. Alex. Petrunkevitch, Short Hills, N. J.; T. D. A. Cockerell, Boulder, Colo.; W. Newell, Baton Rouge, La.; J. C. Hambleton, Columbus, O.; George Ainslee, St. Anthony Park, Minn.; G. P. Weld, Evanston, Ill.

ELECTION OF THE FOLLOWING FELLOWS.

Mark Vernon Slingerland; Justus Watson Folsom; William Joseph Holland; Clarence Preston Gillette; Henry Clinton Fall; Charles Lester Marlatt; Lawrence Bruner.

THE FOLLOWING RESOLUTIONS ON PUBLICATION.

1. That the Society undertake a publication to be called Annals of the Entomological Society of America, to be issued in quarterly fascicles.

2. That it include only papers of importance or marked merit, and that each be issued and bound separately as well as in facsicles so that each paper may be sold separately.

3. That proceedings of the meetings be included either at the beginning or the end of each volume and form one separate which is to be sent to all members of the Society.

4. That a subscription price of One Dollar in addition to the membership fee be charged to members for the Annals and that the subscription price to non- members, libraries, etc., be Three Dollars.

5. That an Editorial Board be selected by the Executive Committee and that this Board shall select one of its members as Managing Editor who with his Associates shall be responsible for the selection of material to be published.

6. That if possible some one living in a suitable location and who can undertake the work of Managing Editor for a series of years, be selected for this position.

7. That details not covered in this report are to be determined by the Editorial Board.

8. That actual publication under the provisions of this report be inaugurated as soon as possible.

Moved by Dr. Smith and seconded by Prof. Sanderson that the report be adopted. Dr. Needham moved to amend, to adopt report except the articles on publication. Motion carried as amended. Dr. Howard moved the adoption of the resolutions on publication, and this was seconded.

Dr. Needham asked where the funds were coming from. Prof. Osborn stated that the subscription plan embodied in the report was counted upon to provide these, but that the date of starting publication was left to the judgment of the committee, and need not be done until the funds were guaranteed. Prof. Sanderson asked what estimate was placed upon the cost of publication. Prof. Osborn said, roughly, $1.000. Dr. Smith said that there were no obligations imposed as to size, and that members would receive the proceedings of the meetings without extra cost, but would pay for the remainder. The idea was the outcome of the

almost universal demand for something of the sort to hold the membership together. In response to question from Mr. Hammar, the Chair stated that it was provided that the Executive Committee should elect the Board of Editors, and Dr. Smith remarked that they need not be members of the Committee, nor necessarily Fellows of the Society.

The motion to adopt the resolution on publication embodied in the report of the Executive Committee was then passed.

The Secretary announced the death of E. H. Davis, of Honolulu, a charter member of this Society.

Dr. Fernald moved:

1. That the Entomological Society of America hereby endorses the Code of Nomenclature adopted by the International Zoological Congress as the Code which should be used by the members of the Society so far as it can be applied.

2. That cases not covered by this Code, which may be presented to the Society for consideration, be referred to a Standing Committee on Nomenclature to consist of three members, one member of which shall be elected each year for a term of three years, and the opinions of this committee on cases referred to them, shall be reported to the Society at the first annual meeting subsequent to their reference to the Committee.

Seconded by Dr. Smith.

Dr. Fernald stated that we could either individually or as a body present such questions to the Zoological Congress.

Mr. Bradley moved to amend by dropping the second clause, "because," he said, "Entomology should not be treated as distinct from Zoology in general, and because the commission on Nomenclature of the Zoological Congress is the sufficient and proper body before which to bring such questions for decision."

Prof. Fernald stated that the reports of the Commission on Nomenclature of the International Congress were greatly delayed by the fact that the congress met only once in three years and by the rule that a question must be presented at least a year before the meeting at which it is to be considered. It was not the intention of the motion that the Committee should act in opposition to or independently of the Commission on Nomenclature, but that it should be instrumental in voicing the needs of entomology before that body, which should be the final court of reference.

With that explanation the amendment was withdrawn. Resolution passed.

Prof. Washburn moved that it is the sense of this meeting that fellowship for the present be limited to ten per cent. of the membership.

Dr. Smith said that the Executive Committee had experienced much difficulty in drawing the line in regard to fellowship. They hoped for some guidance from the Society and a certain limit beyond which they might not pass.

Prof. Summers believed in limiting the number as far as possible. Dr. Felt pointed out that the constitution seems to indicate that a Fellow should be elected on account of strong merit, and that a definite number would not help matters. Several of our present Fellows were unavailable for office and we had but few from whom to select officers.

Dr. Fletcher said that he felt we needed more active men on the list.

Dr. Smith said that there were other men in the Society who were fit to be Fellows, but that the question to decide was whether the list should be a large one from which to draw officers, or a small one for honor.

Prof. Sanderson suggested that some of the present list might be made Honorary Fellows.

Mr. Bradley asked whether a constitutional amendment, providing that members of the Executive Committee need not be drawn from the list of Fellows, would be of any aid.

Dr. Felt said that he thought Honorary Fellows should be very limited and a great honor, but that ordinary Fellows were more like those of the A. A. A. S. and that there was strength in a large number.

Division was called upon Dr. Washburn's motion, and upon show of hands the motion was declared passed.

The Chairman read to the Society a part of a letter from Dr. S. H. Scudder of Cambridge, in which he said, "Please bear my greetings to my good Entomological friends at the Chicago meeting of the Entomological Society of America." The keen interest felt in the Society by Dr. Scudder was mentioned.

The following nominations for officers received in accordance with Dr. Riley's motion, were posted.

President, Dr. J. B. Smith, Dr. Wheeler, Dr. L. O. Howard, Dr. Fletcher.

First Vice President, Dr. Smith, Dr. Skinner, Dr. Wheeler, Dr. Fletcher.

Second Vice President, Dr. Forbes, Dr. Folsom, Dr. Bethune, Dr. J. B. Smith.

Secretary-Treasurer, Dr. Needham, Mr. Adams, Mr. Bradley.

Executive Committee, Drs. Needham, Calvert, Folsom, Fletcher, J. B. Smith, Skinner, Profs. H. Osborn, Comstock, Kellogg, Gillette and Bruner, and Mr. F. M. Webster.

The ballots were then taken and the meeting adjourned until after lunch, Prof. Summers and Dr. Betten acting as tellers.

At 1:45 the meeting was again called to order. The Secretary announced that the following officers had been elected:

President, Dr. W. M. Wheeler.

First Vice President, Dr. J. B. Smith.

Second Vice President, Rev. Prof. C. J. S. Bethune.

Secretary-Treasurer, J. C. Bradley.

Additional members of the Executive Committee:—Prof. J. H. Comstock, Dr. J. G. Needham, Dr. P. P. Calvert, Prof. Herbert Osborn, Mr. F. M. Webster, Prof. V. L. Kellogg.

Dr. Smith offered the following resolution which was adopted:

Resolved, that the thanks of this Society be extended to the University of Chicago for the accommodations furnished and courtesies offered to it, and

Resolved, further, that the thanks of this Society be extended to the Entomological Section of the Chicago Academy of Sciences and to its members individually for the entertainment given to our Society and its members during the meeting.

Mr. Weed moved that Prof. H. T. Fernald be elected member of the Committee on Nomenclature to serve for three years. Seconded by Bradley. Carried.

Mr. Bradley moved that Prof. T. D. A. Cockerell be elected a member of this Committee to serve for two years. Seconded by Mr. Ruggles. Carried.

Dr. Smith moved that Dr. Felt be elected member to serve for one year. Seconded by Prof. Washburn. Carried.

The meeting discussed informally several Entomological topics while awaiting the arrival of Mr. C. F. Jackson, who had a paper entitled, "*Observations on the Life History and Adaptation of a new semi-aquatic Aphid.*" (Habits, life history and specialization of Aphis aquaticus nov. found on water thyme; many remarkable adaptations to its semi-aquatic life). [Published *Ohio Naturalist*, Jan., 1908.]

As Mr. Jackson did not appear the paper was read by title only and the meeting adjourned sine die.

J. CHESTER BRADLEY, *Secretary-Treasurer*.

During the session an exhibit of entomological specimens and materials was open for the inspection of those interested. The titles of the exhibit are given below:

Some enlarged Photographs of Fossil Insects. Chas. T. Brues.

New Devices in Economic Entomology. W. E. Hinds.

Stereoscopic Pictures of Insects. Professor F. L. Washburn.

Dimorph of Chaitophorus negundinis Thos. John J. Davis.

Case of Fall Webworm Moths (Hyphantria textor and H. Cunea). Showing range of Variation of the Latter; Inflated Larvæ. Henry H. Lyman.

Entomological Specimens and Equipment; Interesting Insects from Mexico, Cuba, and Indo-Australia; New Species of Dynastes, etc. Dr. G. Lagai.

Stereoscopic Photographs of Oryssidæ Taken with the Camera Attachment to the Zeiss Greenough Binocular Microscope. Mouth parts of Siricidæ. J. Chester Bradley.

Stereoscopic Photograph of a Tenebrionid Beetle Taken with an Ordinary Camera Using an Eccentric Diaphragm. C. R. Crosby and J. C. Bradley.

The portrait of Dr. Scudder which forms the frontispiece for this number, will certainly be a welcome sight to all our members whether they have had the privilege of personal acquaintance with him or not. "It was taken by a friend one summer afternoon as he sat reading on the veranda. It is the latest picture and the best."

NOTES ON A CHALCID (Syntomaspis druparum Boh.) INFESTING APPLE SEEDS.

By CYRUS R. CROSBY, Cornell University, Ithaca, N. Y.

(Abstract.)

On July 27, 1906, while examining some crab apples at Ithaca, N. Y., for the apple maggot, Rhagolitis pomonella Walsh, the writer noticed that many seeds contained a small Hymenopterous larva. It occupied only a small portion of the interior and was evidently devouring the kernel. During the remainder of the summer the seeds were examined at frequent intervals, and it was found that the larvæ gradually increased in size while the kernel slowly disappeared until in September the larva alone occupied the cavity of the seed.

Egg-laying was not observed, but as the female is provided with a long ovipositor it is probable that the eggs are inserted directly into the young seed while the apple is very small. The full-grown larva passes the winter in the seeds and in May pupates. The adults appeared in June. Specimens were sent to Dr. L. O. Howard who determined them as probably Syntomaspis druparum Boh.

An account of the occurrence of this insect in Crimea where it infests the seeds of the wild apple has been published by Sigismond Mokshetsky (Ztschr. Wiss. Insbiol., II, pp. 390–392, 1906) under the name of Syntomaspis pubescens Forst. I have compared adults reared at Ithaca with specimens kindly sent me by Mokshetsky and find that they are without doubt the same species.

This insect is of interest not only on account of its being the only representative of the genus known to be phytophagic in the larval state, the other species being parasites, but also because it may possibly become an important horticultural pest. It is generally distributed in New York State and infests the native wild apple, Malus coronaria, as well as a number of cultivated varieties.

THE POLYMORPHISM OF ANTS.*

By William Morton Wheeler.

There is a sense in which the term polymorphism is applicable to all living organisms, since no two of these are ever exactly alike. But when employed in this sense, the term is merely a synonym of "variation," which is the more apt, since polymorphism has an essentially morphological tinge, whereas variation embraces also the psychological, physiological, and ethological differences between organisms. In zoölogy the term polymorphism is progressively restricted, first, to cases in which individuals of the same species may be recognized as constituting two or more groups, or castes, each of which has its own definite characters or complexion. Second, the term is applied only to animals in which these intraspecific groups coexist in space and time and do not arise through metamorphosis or constitute successive generations. Cases of the latter description are referred to "alternation of generations" and "seasonal polymorphism." And third, the intraspecific groups which coincide with the two groups of reproductive individuals in all gonochoristic, or separate-sexed Metazoa are placed in the category of "sex" or "sexual dimorphism." There remain, therefore, as properly representing the phenomena of polymorphism only those animals in which characteristic intraspecific and intrasexual groups of individuals may be recognized, or, in simpler language, those species in which one or both of the sexes appear under two or more distinct forms.

As thus restricted polymorphism is of rare occurrence in the animal kingdom and may be said to occur only in colonial or social species where it is commonly attributed to a physiological division of labor. It attains its clearest expression in the social insects, in some of which, like the termites, we find both sexes equally polymorphic, while in others like the ants, social bees, and wasps, the female alone, with rare exceptions, is differ-

* Abstract of an address before the Entomological Society of America December 28, 1906, and published in full in the Bulletin of the American Museum of Natural History, Vol. XXIII, Article I, Jan. 15, 1907, pp. 1–93, pll. I–VI. Only the more general considerations are embodied in this abstract; for a detailed account of the effects of Orasema, Lomechusa, Xenodusa and Mermis parasitism in ants, the reader is referred to the complete work.

entiated into distinct castes. This restriction of polymorphism to the female in the social Hymenoptera, with which we are here especially concerned, is easily intelligible if it be traceable, as is usually supposed, to a physiological division of labor, for the colonies of ants, bees, and wasps are essentially more or less permanent families of females, the male representing merely a fertilizing agency temporarily intruding itself on the activities of the community at the moment it becomes necessary to start other colonies. We may say, therefore, that polymorphism among social Hymenoptera is a physical expression of the high degree of social plasticity and efficiency of the female among these insects. This is shown more specifically in two characteristics of this sex, namely the extraordinary intricacy and amplitude of her instincts, which are thoroughly representative of the species, and her ability to reproduce parthenogenetically. This, of course, means a considerable degree of autonomy even in the reproductive sphere. But parthenogenesis, while undoubtedly contributing to the social efficiency of the female, must be regarded and treated as an independent phenomenon, without closer connection with polymorphism, for the ability to develop from unfertilized eggs is an ancient characteristic of the Hymenoptera and many other insects, which made its appearance among the solitary species, like the Tenthredinidæ and Cynipidæ, long before the development of social life. Moreover, polymorphism may occur in male insects which, of course, are not parthenogenetic. That parthenogenesis is intimately connected with sexual dimorphism, at least among the social Hymenoptera, seems to be evident from the fact that the males usually if not always develop from unfertilized, the females from fertilized eggs.

While the bumble-bees and wasps show us incipient stages in the development of polymorphism, the ants as a group, with the exception of a few parasitic genera that have secondarily lost this character, are all completely polymorphic. It is conceivable that the development of different castes in the female may have arisen independently in each of the three groups of the social Hymenoptera, although it is equally probable that they may have inherited a tendency to polymorphism from a common extinct ancestry. On either hypothesis, however, we must admit that the ants have carried the development of the female castes much further than the social bees and wasps, since they have not only produced a wingless form of the worker, in addition to the winged

female, or queen, but in many cases also two distinct castes of workers known as the worker proper and the soldier.

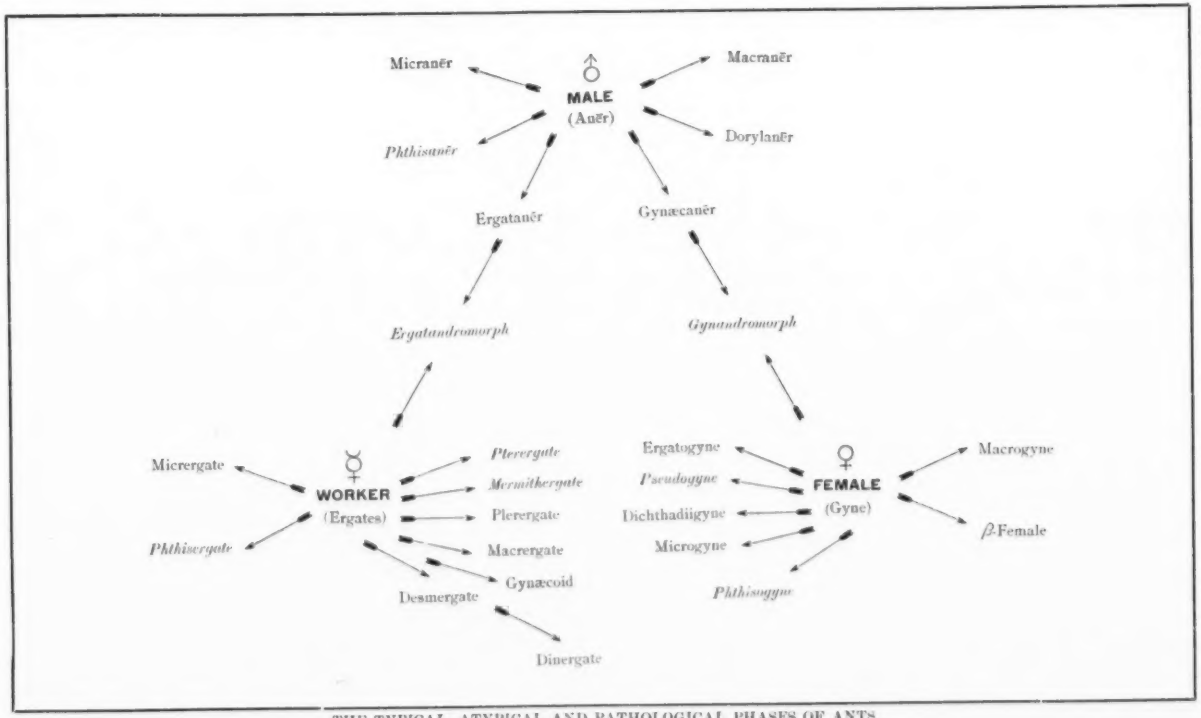
Different authors have framed very different conceptions of the phylogenetic beginnings of social life among the Hymenoptera and consequently also of the phylogenetic origin and development of polymorphism. Thus Herbert Spencer (1893) evidently conceived the colony as having risen from a consociation of adult individuals and although he unfortunately selected a parasitic ant, the amazon (Polyergus rufescens), on which to hang his hypothesis, there are a few facts which seem at first sight, to make his view applicable to other social Hymenoptera. Fabre (1894) once found some hundreds of specimens of a solitary wasp (Ammophila hirsuta) huddled together under a stone on the summit of Mt. Ventoux in the Provence at an altitude of about 5,500 feet, and Forel (1874) found more than fifty deälated females of Formica rufa under similar conditions on the Simplon. I have myself seen collections of a large red and yellow Ichneumon under stones on Pike's Peak at an altitude of more than 13,000 feet, and a mass of about seventy deälated females of Formica gnava apparently hibernating after the nuptial flight under a stone near Austin, Texas. I am convinced, however, that such congregations are either entirely fortuitous, especially where the insects of one species are very abundant and there are few available stones, or that they are, as in the case of F. rufa and gnava, merely a manifestation of highly developed social proclivities and not of such proclivities in process of development.

A very different view from that of Spencer is adopted by most authors, who regard the insect society as having arisen, not from a chance concourse of adult individuals but from a natural affiliation of mother and offspring. This view, which has been elaborated by Marshall (1889) among others, presents many advantages over that of Spencer, not the least of which is its agreement with what actually occurs in the founding of the existing colonies of wasps, bumble-bees and ants. These colonies pass through an ontogenetic stage which has all the appearance of repeating the conditions under which colonial life first made its appearance in the phylogenetic history of the species—the solitary mother insect rearing and affiliating her offspring under conditions that would seem to arise naturally from the breeding habits of the nonsocial Hymenoptera. The exceptional methods of colony formation seen in the swarming of the honey bee

and in the temporary and permanent parasitism of certain ants, are too obviously secondary and of too recent a development to require extensive comment. The bond which held mother and daughters together as a community was from the first no other than that which binds human societies together—the bond of hunger and affection. The daughter insects in the primitive colony became dependent organisms as a result of two factors: inadequate nourishment and the ability to pupate very prematurely. But this very ability entailed an incompleteness of imaginal structure and instincts, which in turn must have confirmed the division of labor and thus tended to perfect the social organization.

Before further discussing the problems suggested by this view of the origin of the colony and the general subject of polymorphism it will be advisable to pass in review the series of different phases known to occur among ants. This review will be facilitated by consulting the accompanying diagram, in which I have endeavored to arrange the various phases so as to bring out their morphological relations to one another. The phases may be divided into two main groups, the normal and the pathological. In the diagram the names of the latter are printed in italics. The normal phases may be again divided into primary or typical, and secondary or atypical, the former comprising only the three original phases, male, female, and worker, the latter the remaining phases, which, however, are far from having the same status or frequency. The three typical phases are placed at the angles of an isosceles triangle, the excess developments being place to the right, the defect developments to the left, of a vertical line passing through the middle of the diagram. The arrows indicate the directions of the affinities of the secondary phases and suggest that those on the sides of the triangle are annectant, whereas those which radiate outward from its angles represent the new departures with excess and defect characters.

(1) The **male** (**aner**) is far and away the most stable of the three typical phases which are found in all but a few monotypic and parasitic genera of ants. This is best shown in the general uniformity of structure and coloration which characterize this sex in genera whose female forms (workers and queens) are widely different; e. g., in such a series as Myrmecia, Odontomachus, Cryptocerus, Formica, Pheidole, etc. In all of these genera the males are very similar, at least superficially, whereas the



THE TYPICAL, ATYPICAL AND PATHOLOGICAL PHASES OF ANTS.

workers and females are very diverse. The body of the male ant is graceful in form, one might almost say emaciated. Its sense-organs (especially the eyes and antennæ), wings and genitalia are highly developed; its mandibles are more or less imperfectly developed and in correlation with them the head is proportionally shorter, smaller and rounder than in the females and workers of the same species. Even when the latter phases have brilliant or metallic colors, as in certain species of Macromischa and Rhytidoponera, the males are uniformly red, yellow, brown or black. Yet notwithstanding this monotony of structure and coloration, the male type may present several interesting modifications.

(2) The **macraner** is an unusually large form of male which occasionally occurs in populous colonies.

(3) The **micraner,** or dwarf male, differs from the typical form merely in its smaller stature. Such forms often arise in artificial nests.

(4) The **dorylaner** is an unusually large form peculiar to the driver and legionary ants of the subfamily Dorylinæ (Dorylus and Eciton). It is characterized by its large and peculiarly modified mandibles, long cylindrical gaster and singular genitalia. It may be regarded as an aberrant macraner that has come to be the typical male of the Dorylinæ.

(5) The **ergataner**, ergatomorphic, or ergatoid male resembles the worker in having no wings and in the structure of the antennæ. It occurs in the genera Ponera, Formicoxenus, Symmyrmica and Cardiocondyla. In certain species of Ponera (P. punctatissima and ergatandria) and in Formicoxenus nitidulus the head and thorax are surprisingly worker-like, in other forms like Symmyrmica chamberlini these parts are more like those of the ordinary male ant, while P. eduardi shows an intermediate development of the head with a worker-like thorax. Forel (1904) has recently found that the ergataner may coexist with the aner, at least in one species of Ponera (P. eduardi Forel). In other words, this ant has dimorphic males.

(6) The **gynæcaner**, or gynæcomorphic male occurs in certain parasitic and workerless genera (Anergates and Epœcus) and resembles a female rather than a worker form. The male of Anergates is wingless, but has the same number of antennal joints as the female. In Epœcus both sexes are very much alike and both have 11–12 jointed antennæ (Emery 1906).

(7) The **phthisaner** is a pupal male which in its larval or semi-pupal state has its juices partially exhausted by an Orasema larva. This male is too much depleted to pass on to the imaginal stage. The wings are suppressed and the legs, head, thorax, and antennæ remain abortive.

(8) The **female (gyne),** or queen, is the more highly specialized sex among ants and is characterized, as a rule, by her larger stature and the more uniform development of her organs. The head is well developed and provided with moderately large eyes, ocelli, and mandibles; the thorax is large (macronotal) and presents all the sclerites of the typical female Hymenopteron; the gaster is voluminous and provided with well developed reproductive organs. The latter possess a receptaculum seminis. The wings and legs are often proportionally smaller than in the male.

(9) The **macrogyne** is a female of unusually large stature.

(10) The **microgyne,** or dwarf female, is an unusually small female which in certain ants, like Formica microgyna and its allies, is the only female of the species and may be actually smaller than the largest workers. In other ants, like certain species of Leptothorax and Myrmica, microgynes may sometimes be found in the same nests as the typical females.

(11) The *β*–**female** is an aberrant form of female such as occurs in Lasius latipes, either as the only form or coexisting with the normal female, which is then called the *α*-female. In this case, therefore, the female is dimorphic. The *β*-female is characterized by excess developments in the legs and antennæ and in the pilosity of the body, or by defective development of the wings.

(12) The **ergatogyne,** ergatomorphic, or ergatoid female, is a worker-like form, with large eyes, ocelli, and a thorax more or less like that of the female, but without wings. Such females occur in a number of species of ants. They have been seen in Myrmecia, Odontomachus, Anochetus, Ponera, Polyergus, Leptothorax, Monomorium and Cremastogaster. There is nothing to prove that they are pathological in origin. In fact, in Monomorium floricola, and certain species of Anochetus they appear to be the only existing females. In other cases, like Ponera eduardi, as Forel has shown, they occur with more or less regularity in nests with normal workers. They also occur under similar conditions in colonies of the circumpolar P. coarctata, and probably also among other species of the genus.

(13) The **pseudogyne** is a worker-like form with enlarged mesonotum and sometimes traces of other thoracic sclerites of the female but without wings or very rarely with wing vestiges. This form occurs in Formica colonies infested with parasitic beetles of the genera Lomechusa and Xenodusa.

(14) The **phthisogyne** arises from a female larva under the same conditions as the phthisaner, and differs from the typical female in the same characters, namely absence of wings, stenonoty, microcephaly and microphthalmy. It is unable to attain to the imaginal instar.

(15) The **worker** (**ergates**) is characterized by the complete absence of wings and a very small (stenonotal) thorax, much simplified in the structure of its sclerites. The eyes are small and the ocelli are usually absent or, when present, extremely small. The gaster is small owing to the undeveloped condition of the ovaries. A receptaculum seminis is usually lacking, and the number of the ovarian tubules is greatly diminished. The antennæ, legs and mandibles are well developed.

(16) The **gynæcoid** is an egg-laying worker. It is a physiological rather than a morphological phase, since it is probable that all worker ants when abundantly fed become able to lay eggs. Wasmann (1904) observed in colonies of Formica rufibarbis that a few workers became gynæcoid and functioned as substitution queens. In colonies of the Ponerine genus Leptogenys (including the subgenus Lobopelta), and probably also in Diacamma and Champsomyrmex, the queen phase has disappeared and has been replaced by the gynæcoid worker.

(17) The **dichthadiigyne,** or dichthadiiform female is peculiar to the ants of the subfamily Dorylinæ, and probably represents a further development of the gynæcoid. If this view of the origin of the dichthadiigyne is held, the name of this form in the diagram should be transferred to the worker side. It is wingless and stenonotal, destitute of eyes and ocelli, or with these organs very feebly developed, and with a huge elongated gaster and extraordinary, voluminous ovaries.

(18) The **macrergate** is an unusually large worker form which is sometimes produced in populous or affluent colonies (Formica, Lasius).

(19) The **micrergate**, or dwarf worker, is a worker of unusually small stature. It appears as a normal or constant form in the first brood of all colonies that are founded by isolated females.

(20) The **dinergate,** or soldier, is characterized by a huge head and mandibles, often adapted to particular functions (fighting and guarding the nest, crushing seeds or hard parts of insects), and a thoracic structure sometimes approaching that of the female in size or in the development of its sclerites (Pheidole).

(21) The **desmergate** is a form intermediate between the typical worker and dinergate, such as we find in more or less isolated genera of all the subfamilies except the Ponerinæ, e. g., in Camponotus, some species of Pheidole, Solenopsis, Pogonomyrmex, Azteca, Dorylus, Eciton, etc. The term may also be employed to designate the intermediate forms between the small and large workers in such genera as Monomorium, Formica, etc.

(22) The **plerergate**, "replete", or "rotund," is a worker which in its callow stage has acquired the peculiar habit of distending the gaster with stored liquid food ("honey") till it becomes a large spherical sac and locomotion is rendered difficult or even impossible. This occurs in the honey ants (some North American species of Myrmecocystus, some Australian Melophorus and Camponotus, and in a less extreme form in certain species of Prenolepis and Plagiolepis).

(23) The **pterergate** is a worker or soldier with vestiges of wings on a thorax of the typical ergate or dinergate form, such as occurs in certain species of Myrmica and Cryptocerus.

(24) The **mermithergate** is an enlarged worker, produced by Mermis parasitism and often presenting dinergate characters in the thorax and minute ocelli in the head.

(25) The **phthisergate**, which corresponds to the phthisogyne and phthisaner, is a pupal worker which in its late larval or semipupal stage has been attacked and partially exhausted of its juices by an Orasema larva. It is characterized by extreme stenonoty, macrocephaly and microphthalmy, and is unable to pass on to the imaginal stage. It is in reality an infra-ergatoid form.

(26) The **gynandromorph** is an anomalous individual in which male and female characters are combined in a blended or more often in a mosaic manner.

(27) The **ergatandromorph** is an anomaly similar to the last but having worker instead of female characters combined with those of the male. (Wheeler, 1903.)

It is usually stated that the fertilization or non-fertilization of the egg of the social Hymenopteron determines whether it shall give rise to a male or female. And as the queen represents the

typical female form of the species, the problem of polymorphism is to account for the various worker forms, and those like the soldiers, pseudogynes and ergatoid females which are more or less intermediate between the worker and the queen. The ergatomorphic males are regarded as having inherited worker characters. Thus the problem of polymorphism centers in the development of the worker. It must suffice in this place to give the briefest possible statement of the views of the various authors who have endeavored to account for the development of this caste. These authors may be divided into three groups:

1. Those who believe, with Weismann, that the various castes are represented in the egg by corresponding units (determinants). Fertilization is then regarded as the stimulus which calls the female determinants into activity and meager feeding the stimulus which arouses the worker-producing determinants in the young larvæ arising from fertilized eggs. Such an explanation is obviously little more than a restatement, or "photograph" of the problem. It seeks to account for the adaptive characters of the worker forms through natural selection acting on fortuitous congenital variations.

2. Those who believe, with Herbert Spencer, that there is no such preformation of the various female castes, but that these are produced epigenetically by differences in the feeding of the larvæ. The workers simply arise from larvæ that are inadequately fed but are nevertheless able to pupate and hatch when only a part of their growth has been completed. This is not, like the preceding view, a restatement of the problem, since the modifications induced by inadequate feeding are conceived as somatic and not as germinal, but it fails to explain how the worker caste acquires its adaptive characters, unless this caste is supposed to reproduce with sufficient frequency to transmit acquired somatic modifications to the germ-plasm of the species.

3. A third group of investigators believes, with Emery, that the germ-plasm of the social Hymenopteron is indeed implicated in the phenomenon, not, however, as possessing separate sets of determinants, but as being in a labile or sensitive condition and therefore capable of being deflected along different developmental paths by differences in the trophic stimuli acting on the larva. According to Emery, "the peculiarities in which the workers differ from the corresponding sexual forms are, therefore, not innate or blastogenic, but acquired, that is somatogenic. Nor are they

transmitted as such, but in the form of a peculiarity of the germplasm that enables this substance to take different developmental paths during the ontogeny. Such a peculiarity of the germ may be compared with the hereditary predisposition to certain diseases, which like hereditary myopia develop only under certain conditions. The eye of the congenitally myopic individual is blastogenetically predisposed to short-sightedness, but only becomes short-sighted when the accommodation apparatus has been overtaxed by continual exertion. Myopia arises, like the peculiarities of the worker ants, as a somatic affection on a blastogenic foundation.

"With this assumption the problem of the development of workers seems to me to become more intelligible and to be brought a step nearer its solution. The peculiarities of the Hymenopteron workers are laid down in every female egg; those of the termite workers in every egg of either sex, but they can only manifest themselves in the presence of specific vital conditions. In the phylogeny of the various species of ants the worker peculiarities are not transmitted but merely the faculty of all fertilized eggs to be reared as a single or as several kinds of workers. The peculiar instinct of rearing workers is also transmitted since it must be exercised by the fertile females in establishing their colonies."

The views above cited show very clearly that authors have been impressed by very different aspects of the complicated phenomena of polymorphism, and that each has emphasized the aspect which seemed the most promising from the standpoint of the general evolutionary theory he happened to be defending. Escherich (1906) has recently called attention to two very different ways of envisaging the problem; one of these is physiological and ontogenetic, the other ethological and phylogenetic. As these furnish convenient headings under which to continue the discussion of the subject, I shall adopt them, and conclude with a third, the psychological aspect, which is certainly of sufficient importance to deserve consideration.

While the ontogeny of nearly all animals is a repetition or reproduction of the ontogeny of the parent, this is usually not the case in the social Hymenoptera, since the majority of their fertilized eggs do not give rise to queens but to more or less aberrant organisms, the workers. And as these do not, as a rule, reproduce, the whole phenomenon is calculated to arouse the interest of both the physiologist and the embryologist. The former, con-

centrating his attention on the reactions of the animal to the stimuli proceeding from its environment, is inclined to study its later stages as determined by the reactions to such stimuli, without regard to any internal or hereditary predetermination or disposition, while the embryologist seeks out the earliest moment at which the organism may be shown to deviate from the ontogenetic pattern of its parent. If this moment can be detected very early in the development he will be inclined to project the morphological differentiation back into the germ-plasm and to regard the efforts of the physiologist as relatively unimportant if not altogether futile. Now in his study of the social insects the embryologist is at a serious disadvantage, since he is unable to distinguish any prospective worker or queen characters in the eggs or even in the young larvæ. Compelled, therefore, to restrict his investigations to the older larvæ, whose development as mere processes of histogenesis and metamorphosis throws little or no light on the meaning of polymorphism, he is bound to abdicate and leave the physiologist in possession of the problem.

The physiologist in seeking to determine whether there is in the environment of the developing social Hymenopteron any normal stimulus that may account for the deviation towards the worker or queen type, can hardly overlook one of the most important of all stimuli, the food of the larva. At first sight this bids fair greatly to simplify the problem of polymorphism, for the mere size of the adult insect would seem to be attributable to the quantity, its morphological deviations to the quality of the food administered to it during its larval life. Closer examination of the subject, however, shows that larval alimentation among such highly specialized animals as the social insects, and especially in the honey-bees and ants, where the differences between the queens and workers are most salient, is a subject of considerable complexity. In the first place, it is evident that it is not the food administered that acts as a stimulus but the portion of it that is assimilated by the living tissues of the larva. In other words, the larva is not altogether a passive organism, compelled to utilize all the food that is forced upon it, but an active agent, at least to a certain extent, in determining its own development. And the physiologist might have difficulty in meeting the assertion that the larva utilizes only those portions of the proffered food which are most conducive to the specific predetermined trend of its development. In the second place,

while experiments on many organisms have shown that the quantity of assimilated food may produce great changes in size and stature, there is practically nothing to show that even very great differences in the quality of the food can bring about morphological differences of such magnitude as those which separate the queens and workers of many ants.

These more general considerations are reinforced by the following inferences from the known facts of larval feeding:

1. There seems to be no valid reason for supposing that the morphogeny of the queens among the social Hymenoptera depends on a particular diet, since with the possible exception of the honey and stingless bees, to be considered presently, they differ in no essential respect from the corresponding sexual phase of the solitary species. In both cases they are the normal females of the species and bear the same morphological relations to their males quite irrespective of the nature of their larval food. Hence, with the above mentioned exception, the question of the morphogenic value of the larval food may be restricted to the worker forms.

2. Observation shows that although the food administered to the larvæ of the various social insects is often very different in its nature, even in closely related species, the structure of the workers may be extremely uniform and exhibit only slight specific differences. Ant larvæ are fed with a great variety of substances. The quality of the food itself cannot, therefore, be supposed to have a morphogenic value. And even if we admit what seems to be very probable, namely, that a salivary secretion—possibly containing an enzyme—may be administered by some ants at least to their younger larvæ, the case against the morphogenic effects of qualitative feeding is not materially altered, as we see from the following considerations:

3. In incipient ant-colonies the queen mother takes no food often for as long a period as eight or nine months, and during all this time is compelled to feed her first brood of larvæ exclusively on the secretions of her salivary glands. This diet, which is purely qualitative, though very limited in quantity, produces only workers and these of an extremely small size (micrergates).

4. In the honey-bees, on the other hand, qualitative feeding, namely with a secretion, the so-called "royal jelly," which according to some authors (Schiemenz) is derived from the salivary glands, according to others (Planta) from the chylific stomach of

the nurses, does not produce workers but queens. In this case, however, the food is administered in considerable quantity, and is not provided by a single starving mother, as in the case of the ants, but by a host of vigorous and well-fed nurses. Although it has been taken for granted that the fertilized honey-bee becomes a queen as the result of this peculiar diet, the matter appears in a different light when it is considered in connection with von Ihering's recent observations on the stingless bees (Meliponidæ) of South America (1903). He has shown that in the species of Melipona the cells in which the males, queens, and workers are reared are all of the same size. These cells are provisioned with the same kind of food (honey and pollen) and an egg is laid in each of them. Thereupon they are sealed up, and although the larvæ are not fed from day to day as in the honey-bees, but like those of the solitary bees subsist on stored provisions, this uniform treatment nevertheless results in the production of three sharply differentiated castes. On hatching the queen Melipona has very small ovaries with immature eggs, but in the allied genus Trigona, the species of which differ from the Meliponæ in constructing large queen cells and in storing them with a greater quantity of honey and pollen, the queen hatches with her ovaries full of ripe eggs. These facts indicate that the large size of the queen cell and its greater store of provisions are merely adaptations for accelerating the development of the ovaries. Now on reverting to the honey-bee we may adopt a similar explanation for the feeding of the queen larva with a special secretion like the "royal jelly." As is well known, the queen honey-bee hatches in about sixteen days from the time the egg is laid, while the worker, though a smaller insect and possessing imperfect ovaries, requires four or five days longer to complete her development. That the special feeding of the queen larva is merely an adaptation for accelerating the development of the ovaries is also indicated by the fact that this insect is able to lay within ten days from the date of hatching. If this interpretation is correct the qualitative feeding of the queen larva is not primarily a morphogenic but a growth stimulus.

5. The grossly mechanical withdrawal by parasites like Orasema of food substances already assimilated by the larva, produces changes of the same kind as those which distinguish the worker ant from the queen, i. e., microcephaly, microphthalmy, stenonoty, and aptery. This case is of unusual interest

because the semipupa, after the detachment of the parasite, seems to undergo a kind of regeneration and produces a small but harmonious whole out of the depleted formative substances at its disposal. What is certainly a female or soldier semipupa takes on worker characters while the worker semipupa may be said to become infra-ergatoid as the result of the sudden loss of the formative substances. These observations indicate that the normal worker traits may be the result of starvation or withholding of food rather than of the administration of a particular diet.

6. The pseudogynes of Formica admit of a similar interpretation if it be true, as I am inclined to believe, that they arise from starved female larvæ. Here, too, the organism undergoes a kind of regeneration or regulation and assumes the worker aspect owing to a dearth of sufficient formative substances with which to complete the development as originally planned.

7. In the preceding cases the ants take on peculiar structural modifications as the result of tolerating parasites that bring about unusual perturbations in the trophic status of the colony. When ants themselves become parasitic on other ants a similar perturbation ensues, but in these cases the morphological effects are confined to the parasitic species and do not extend to their hosts. This must be attributed to the fact that the parasites live in affluence and are no longer required to take part in the arduous and exacting labors of the colony. Under such circumstances the inhibitory effects of nutricial castration* on the development of the ovaries of the workers are removed and there is a tendency for this caste to be replaced by egg-laying gynæcoid individuals or by ergatogynes, or for it to disappear completely. These effects are clearly visible in nearly all parasitic ants. In the European Harpegoxenus sublævis, for example, the only known females in

* Nutricial castration (from nutrix, a nurse) as understood by Marchal, must be distinguished from alimentary castration (Emery, Le Polymorphisme, etc.), although both are responsible for the infertility of the worker. Through alimentary castration the development of the reproductive organs is inhibited in the larva and pupa, and this inhibition is maintained in the adult by the strong nursing instincts which prevent the workers from appropriating much of the food supply of the colony to their individual use. In many of the higher animals also (birds, mammals) reproduction is inhibited by the exercise of the nutricial function. A third method of inhibiting or destroying the reproductive function is known to occur in the "parasitic castration" of certain bees and wasps (Andrena, Polistes) by Strepsiptera (Stylops, Xenos, etc.) See Perez, Des Effets du Parasitisme des Stylops sur les Apiaires du Genre Andrena. Actes Soc. Linn. Bordeau, 1886, 40 pp. 2 pll. Westwood has also described a Strepsipteron (Myrmecolax nietneri) which in all probability produces this form of castration in certain Formicidae.

certain localities are gynæcoid workers. In the American Leptothorax emersoni, as I have shown (1903), gynæcoid workers and ergatogynes are unusually abundant while the true females seem to be on the verge of disappearing. Among the typical amazon ants (Polyergus rufescens) of Europe, ergatogynes are not uncommon. In Strongylognathus testaceus the worker caste seems to be dwindling, while in several permanently parasitic genera (Anergates, Wheeleriella, Epœcus, Epipheidole and Sympheidole) it has completely disappeared. Only one cause can be assigned to these remarkable effects—the abundance of food with which the parasites are provided by their hosts.

8. In the Ponerinæ and certain Myrmicinæ, like Pheidole, Pogonomyrmex and Aphænogaster, the larvæ are fed on pieces of insects or seeds, the exact assimilative value of which as food can neither be determined nor controlled by the nurses. And while they may perhaps regulate the quantity of food administered, it is more probable that this must fluctuate within limits so wide and indefinite as to fail altogether to account for the uniform and precise morphological results displayed by the personnel of the various colonies. Moreover, any accurate regulation of the food supply by the workers must be quite impossible in cases like that of the Pachycondyla larva bearing the commensal Metopina.

9. The dependence of the different castes of the social insects on the seasons may also be adduced as evidence of the direct effects of the food supply in producing workers and queens. The latter are reared only when the trophic condition of the colony is most favorable and this coincides with the summer months; in the great majority of species only workers and males are produced at other seasons. Here, too, the cause is to be sought in the deficient quantity of food rather than in its quality, which is, in all probability, the same throughout the year, especially in such ants as the fungus-growing Attii.

While these considerations tend to invalidate the supposition that qualitative feeding is responsible for the morphological peculiarities of the worker type, they are less equivocal in regard to the morphogenic effects of quantitative feeding. Indeed several of the observations above cited show very clearly that diminution in stature and, in pathological cases, even reversion to the worker form may be the direct effect of under-feeding. To the same cause we may confidently assign several of the atypical phases among ants, such as the micrergates, microgynes, and micraners, just

as we may regard the macrergates, macrogynes, and macraners as due to overfeeding. These are, of course, cases of nanism and giantism, variations in stature, not in form. Similiarly, all cases in which, as in certain species of Formica, Camponotus, Pheidole, etc., the workers or desmergates vary in size, must be regarded as the result of variable quantitative feeding in the larval stage. Here we are confronted with the same conditions as Weismann observed in prematurely pupating blow-flies and entomologists have noticed in many other insects. Such variations are of the fluctuating type and are therefore attributable to the direct effects of the environment. The soldier and worker, however, differ from the queen in the absence of certain characters, like the wings, wing-muscles, spermatheca, some of the ovarian tubules, etc., and the presence of other characters, like the peculiar shape of the head and mandibles. In these respects the sterile castes may be regarded as mutants, and Weismann's contention that such characters cannot be produced by external conditions, such as feeding, is in full accord with De Vries's hypothesis. His further contention, however, that they must therefore be produced by natural selection need not detain us, since it is daily becoming more and more evident that this is not a creative but an eliminative principle. It is certain that very plastic insects, like the ants, have developed a type of ontogeny which enables them not only to pupate at an extremely early period of larval life, but also to hatch and survive as useful though highly specialized members of the colony. It is conceivable that this precocious pupation may be directly responsible for the complete suppression of certain organs that require for their formation more substance than the underfed larva is able to accumulate. At the same time it must be admitted that a direct causal connection between underfeeding on the one hand and the ontogenetic loss or development of characters on the other, has not been satisfactorily established. The conditions in the termites which are often cited as furnishing proof of this connection, are even more complicated and obscure than those of the social Hymenoptera. While Grassi and Sandias (1893) and Silvestri (1901) agree with Spencer in regarding feeding as the direct cause of the production of the various castes, Herbst (1901) who has reviewed the work of the former authors, shows that their observations are by no means conclusive; and Heath (1902) makes the following statement in regard to his experiments on Californian termites: "For months I have fed a

large number of termite colonies of all ages, with or without royal pairs, on various kinds and amounts of food—proctodæal food dissected from the workers or in other cases from royal forms, stomodæal food from the same sources, sawdust to which different nutritious ingredients have been added—but in spite of all I cannot feel perfectly sure that I have influenced in any unusual way the growth of a single individual."

This rather unsatisfactory answer to the question as to whether quantity or quality of food or both, have an ergatogenic value, has led some investigators to seek a solution along more indirect lines. Thus O. Hertwig and Herbst suggest that the morphogenic stimulus may be furnished by some internal secretion of the reproductive organs. This, too, is possible, but owing to our very imperfect knowledge of the internal secretions, even in the higher animals, we are not in a position either to accept or reject this suggestion.

We may conclude, therefore, that while the conception of the worker type as the result of imperfect nutrition is supported by a considerable volume of evidence, we are still unable to understand how this result can take on so highly adaptive a character. Such a concise effect can hardly be due to manifold and fluctuating external causes like nutrition, but must proceed from some more deeply seated cause within the organism itself. Of course, the difficulty here encountered is by no means peculiar to polymorphism; it confronts us at every turn as the all-pervading enigma of living matter.

An intensive study of the structure and habits of ants must inevitably lead to a certain amount of speculation concerning the phylogenetic development of their colonies. That these insects have had communistic habits for ages is clearly indicated by the fact that all of the numerous existing species are eminently social. There can be little doubt, however, that they rose from forms with habits not unlike those we find today in some of the solitary wasps, such as the Bembecidæ, or in the remarkable South African bees of the genus Allodape. Unlike other solitary wasps, the females of Bembex may be said to be incipiently social, since a number of them choose a nesting site in common and, though each has her own burrow, cooperate with one another in driving away intruders. Bembex has also taken an important step in the direction of the social wasps not only in surviving the hatching of her larvæ, but also in visiting them from day to day for the purpose of providing them with fresh insect food.

At a very early period the ants and social wasps must have made a further advance when the mother insect succeeded in surviving till after her progeny had completed their development. This seems to have led naturally to a stage in which the young females remained with their mother and reared their progeny in the parental nest, thus constituting a colony of a number of similar females with a common and indiscriminate interest in the brood. This colony, after growing to a certain size, became unstable in the same way as any aggregate of like units, and must soon have shown a differentiation of its members into two classes, one of the individuals devoted to reproduction and another class devoted to alimentation and protection. In this division of labor only the latter class underwent important somatic modification and specialization, while the former retained its primitive and more generalized characters. It is more than probable, as I shall attempt to show in the sequel, that this differentiation was manifested in the sphere of instinct long before it assumed a morphological expression. The social wasps and the bumble-bees are still in this stage of sociogeny. The ants, however, have specialized and refined on these conditions till they have not only a single marked alimentative and protective caste without wings and lacking many other female characters, but in some species two distinct castes with a corresponding further division of labor. In the phylogeny as well as the ontogeny these characters appear as a result of nutricial castration.

If the foregoing considerations be granted the biogenetic law may be said to hold good in the sociogeny of the ants, for the actual ontogenetic development of their colonies conforms not only to the purely conjectural requirements of phylogeny but also to the stages represented by the various extant groups of social insects. It is clear that we cannot include the honey-bee among these groups, since this insect is demonstrably so aberrant that it is difficult to compare it with the other social insects.

Comparison of the different genera and sub-families of ants among themselves shows that some of them have retained a very primitive social organization, and with it a relatively incomplete polymorphism, whereas others have a much more highly developed social life and a greater differentiation of the castes. Such a comparison, coupled with a study of the natural relationships of the various genera as displayed in structure, suggests that the advance from generalized to highly specialized societies

did not follow a single upward course during the phylogeny, but occurred repeatedly and in different phyletic groups. And since the complications of polymorphism kept pace with those of social organizations, we may say that the differentiation of the originally single worker caste into dinergates, or soldiers, on the one hand, and micrergates, or small workers, on the other, has been several times repeated in remotely related genera. In some genera (Stenamma sens. str., Leptothorax) there are also indications of a lapsing of highly specialized into simpler conditions by a kind of social degeneration. In its extreme form this manifests itself as a suppression of castes and a consequent simplification of polymorphism. Beautiful illustrations of this statement are furnished by the parasitic species that have lost their worker caste. But there are also cases in which the queen caste has been suppressed and its functions usurped by workers (Leptogenys).

Not only have these greater changes been effected and fixed during the phylogenetic history of the Formicidæ, but also many subtler differences such as those of stature, coloration, pilosity and sculpture. And although such differences belong to the class of fluctuating variations and are usually supposed to have a greater ontogenetic than phylogenetic significance, they are undoubtedly of great antiquity and must therefore be regarded as more important than many of the minor morphological traits.

Emery was the first to call attention to a number of peculiar phylogenetic stages in the development of stature among ants. (1894). He found by comparison with the male, which is to be regarded as a relatively stable and conservative form, that the cospecific females and workers may vary in stature independently of each other. The following are the stages which he recognized and some additions of my own:

1. In the earliest phylogenetic condition, which is still preserved in the ants of the subfamily Ponerinæ and in certain Myrmicinæ (Pseudomyrma, Myrmecina, etc.), the workers are monomorphic and of about the same size as the males and females.

2. The worker becomes highly variable in stature, from large forms (dinergates, or maxima workers) resembling the female, through a series of intermediates (desmergates, or mediæ) to very small forms (minima workers, or micrergates). This condition obtains in the Dorylinæ, some Myrmicinæ (Pheidole, Pheidologeton, Atta), Camponotinæ (Camponotus) and Dolichoderinæ (Azteca).

3. The worker becomes dimorphic through the disappearance of the desmergates, so that the originally single variable caste is now represented by two, the soldier (dinergate) and worker proper. We find this condition in certain Myrmicinæ and Camponotinæ (Cryptocerus, Pheidole, Acanthomyrmex, Colobopsis, etc.)

4. The soldier of the preceding stage disappears completely, so that the worker caste again becomes monomorphic, but is represented by individuals very much smaller than the female. Such individuals are really micrergates. This condition is seen in certain Myrmicine genera, especially of the tribe Solenopsidii (Carebara, Erebomyrma, Diplomorium, most species of Solenopsis, etc.)

5. The worker form disappears completely leaving only the males and females to represent the species, which thus returns to the condition of sexual dimorphism seen in the great majority of insects and other Metazoa. This occurs in the parasitic ants of the genera Anergates, Wheeleriella, Epœcus, Sympheidole and Epipheidole.

6. In certain species the workers remain stationary while the female increases in size. This is indicated by the fact that the worker and male have approximately the same stature. Such conditions obtain in certain Myrmicinæ (Cremastogaster), Camponotinæ (Lasius, Prenolepis, Brachymyrmex, the North American species of Myrmecocystus), and Dolichoderinæ (Iridomyrmex, Dorymyrmex, Liometopum).

7. The worker caste remains stationary while the female diminishes in size till it may become even smaller than the large workers. This occurs in certain parasitic species of North America, like Aphænogaster tennesseensis among the Myrmicinæ, and among the Camponotinæ in the species of the Formica microgyna group (F. difficilis, nevadensis, impexa, dakotensis, nepticula).

8. The female phase disappears completely and is replaced by a fertile, or gynæcoid worker form. This occurs in certain Ponerine genera like Leptogenys (including the subgenus Lobopelta), and probably also in Diacamma and Champsomyrmex. The conditions in Acanthostichus and certain Cerapachyi (Parasyscia peringueyi) indicate that the dichthadiigynes of the Dorylinæ may have arisen from such gynæcoid workers instead of from winged queens.

9. The female shows a differentiation into two forms (α and β females) characterized by differences in the structure of the legs and antennæ, in pilosity and coloration (Lasius latipes), or in the length of the wings (macropterous and micropterous females of L. niger). The macrocephalic and microcephalic females of Camponotus abdominalis and confusus described by Emery (1896) may also be regarded as α and β forms. In this series, stages one to five represent changes in the worker caste while the female remains relatively stationary, whereas stages six to nine represent the converse conditions. Stages one to four probably succeeded one another in the order given, but stage five may have arisen either from the first or fourth. The sixth to ninth stages, must of course, be supposed to have developed independently of one another.

The stature differences described in the above paragraphs are in most if not all cases, highly adaptive. This is clearly seen in such forms as the Indo-African Carebara, the huge, deeply, colored females of which are more than a thousand times as large as the diminutive, yellow workers. This ant dwells in termite nests where it occupies chambers connected by means of tenuous galleries with the spacious apartments of its host. The termites constitute a supply of food so abundant and accessible that the workers are able to rear enormous males and females, while they themselves must preserve their diminutive stature in adaptation to their clandestine and thievish habits. Similar conditions are found in many species of the allied genus Solenopsis, which inhabit delicate galleries communicating with the nests of other ants on whose larvæ and pupæ they feed. In one species of this genus (S. geminata), however, which leads an independent life and feeds on miscellaneous insects and seeds, the worker caste is still highly polymorphic.

Another interesting case of adaptation in stature is seen in the ants of the Formica microgyna group. The females of these are temporarily parasitic in the nests of other Formicæ and are therefore relieved of the labor of digging nests for themselves and rearing their first brood of larvæ. On this account they need not store up large quantities of food, so that the nourishment which in nonparasitic species goes to produce a comparatively few large females may be applied to the production of a large number of small individuals. This latter condition is, indeed, necessary in parasitic species which are decimated by many

vicissitudes before they can establish themselves successfully among alien hosts. I have already emphasized the adaptive significance of the disappearance of the worker caste among permanently parasitic species like Anergates, Wheeleriella, etc.

There are several cases in which the worker and female differ greatly in color, pilosity or sculpture, and in such cases either caste may be conservative or aberrant according to ethological requirements. Thus in certain temporary parasites like Formica ciliata, oreas, crinita, dakotensis, and difficilis, the female is aberrant in one or more of the characters mentioned, while the cospecific worker retains the ancestral characters of the same caste in the closely allied forms of F. rufa. The same condition is seen in a very different ant, Aphænogaster tennesseensis, as the result of similar parasitic habits. In all of these species the females alone have developed myrmecophilous characters, like the long yellow hairs of F. ciliata, or the mimetic coloring of F. difficilis, which enable them to foist themselves on allied species and thus avoid the exhausting labor of excavating nests and rearing young, whereas the workers remain unmodified.

The foregoing observations indicate that in morphological characters the worker and female of the same species have advanced or digressed in their phylogeny, remained stationary or retrograded, independently of each other. The same peculiarity is also observable in species with distinct worker and soldier castes. It thus becomes impossible, even in closely related species of certain genera, like Pheidole, to predict the characters of the worker from a study of the cospecific soldier or vice versa. And while adaptive characters in stature, sculpture, pilosity and color must depend for their ontogenetic development on the nourishment of the larvæ, it is equally certain that they have been acquired and fixed during the phylogeny of the species. In other words, nourishment, temperature, and other environmental factors merely furnish the conditions for the attainment of characters predetermined by heredity. We are therefore compelled to agree with Weismann that the characters that enable us to differentiate the castes must be somehow represented in the egg. We may grant this however, without accepting his conception of representative units, a conception which has been so often refuted that it is unnecessary to reconsider it in this connection.

Having touched upon this broader problem of heredity it will be necessary to say something about the inheritance or non-inher-

itance of acquired characters, especially as Weismann and his followers regard the social insects as demonstrating the non-transmissibility of somatogenic traits. In establishing this view and the all-sufficiency of natural selection to which it leads, Weismann seems to me to have slurred over the facts. While he admits that the workers may lay eggs, and that these may produce male offspring capable of fertilizing females, he nevertheless insists that this is altogether too infrequent to influence the germ-plasm of the species. I venture to maintain, on the contrary that fertile workers occur much more frequently in all groups of social insects than has been generally supposed. As this fertility is merely a physiological state it has been overlooked. Marchal has shown how readily the workers of the social wasps assume this state, and the same is true of the honey-bees, especially of certain races like the Egyptians and Cyprians (Apis mellifica, fasciata and cypria). In the hives of these insects fertile workers are either always present or make their appearance within a few days after the removal of the queen. Among termites fertile soldiers have been observed by Grassi and Sandias and fertile workers by Silvestri. Among ants fertile, or gynæcoid, workers occur so frequently as to lead to the belief that they must be present in all populous colonies. Their presence is also attested by the production of considerable numbers of males in old and queenless communities. In artificial nests Wasmann, (1891), Miss Fielde (1905) and myself have found egg-laying workers in abundance.

Now as the males that develop from worker eggs are perfectly normal, and in all probability as capable of mating as those derived from the eggs of queens, we are bound to conclude, especially if we adopt the theory of heredity advocated by Weismann himself, that the characters of the mother (in this case the worker) may secure representation in the germ-plasm of the species. Weismann is hardly consistent in denying the probability of such representation, for when he is bent on elaborating the imaginary structure of the germ-plasm he makes this substance singularly retentive of alteration by amphimixis, but when he is looking for facts to support the all-sufficiency of natural selection the germ-plasm becomes remarkably difficult of modification by anything except this eliminative factor. Certainly the simplest and directest method of securing a representation of the worker characters in the germ-plasm would be to get them from the worker itself that has survived in the struggle for existence, rather than through

the action of natural selection on fortuitous constellations of determinants in the germ-plasm of the queen. If we grant the possibility of a periodical influx of worker germ-plasm into that of the species, the transmission of characters acquired by this caste is no more impossible than it is in other animals, and the social insects should no longer be cited as furnishing conclusive proof of Weismannism.

Plate has attempted to overcome the difficulties presented by the normal sterility of the worker by supposing that the distinguishing characters of this caste arose prior to its inability to reproduce. He recognizes the following stages in the phylogeny of the social insects.

"1. The presocial stage with but a single kind of male and female.

"2. The social stage with but a single kind of male and female. The peculiarities in nesting, caring for the brood, and other instincts were already developed during this stage.

"3. The social stage with one kind of male and two or several kinds of females, which were all fertile, but in consequence of the physiological division of labor became more and more different in the course of generations. The division of labor took place in such a manner that the sexual functions passed over primarily to a group A, while the construction of the nest, predatory expeditions and other duties devolved mainly on another group of individuals (B) which on that account used their reproductive organs less and less.

"4. The present stage with one kind of male, a fertile form of female, which arose from group A, and one or several kinds of sterile females, or workers (group B)."

Plate assumes that the differentiation into sterile and fertile forms did not take place till stage 3, and if I understand him correctly, not till after "the races had become differentiated morphologically." This view, as he admits, resembles Spencer's. The two views, in fact differ merely in degree, for the underlying contention is the same, namely that sterility is one of the most recently developed characters among the social insects. There can be little doubt, however, that the smaller adaptive characters, for example those of the females of certain Formicæ above mentioned, must have made their appearance in the fourth stage of Plate's scheme. The view which I have advocated differs from Plate's in admitting that even in this stage the workers are fertile

with sufficient frequency to maintain a representation of their characters in the germ-plasm of the species. Conclusive evidence of the presence or absence of such representation can be secured only by experimental breeding and especially by hybridizing the male offspring of workers of one species (a), with females of another (b) that has workers of a different character. Under these conditions some of the characters of (a) should make their appearance in (b).

In the foregoing discussion attention has been repeatedly called to adaptation as the insurmountable obstacle to our every endeavor to explain polymorphism in current physiological terms. Of course, this is by no means a peculiarity of polymorphism, for the same difficulty confronts us in every biological inquiry. As the type of polymorphism with which we are dealing has been developed by psychically highly endowed social insects, it cannot be adequately understood as a mere morphological and physiological manifestation apart from the study of instinct. This has been more or less distinctly perceived by nearly all writers on the subject. However various their explanations, Spencer, Weismann, Emery, Forel, Marchal, and Plate all resort to instinct. Emery, especially, has seen very clearly that a worker type with its peculiar and aberrant characteristics could not have been developed except in a living environment consisting of the fostering queen and workers which instinctively control the development of the young in so far as this depends on external factors. The worker caste may be regarded as a mutation comparable with some of De Vries's Œnothera mutations, but able to repeat and maintain itself for an indefinite series of generations in perfect symbiosis with its parent form, the queen, because, notwithstanding its relative infertility, it can be put to very important social use. Among ants this social use not only pervades the activities of the adult workers but extends even to the more inert larval stages. Thus the latter represent a rich and ever-fresh supply of food that can be devoured whenever a temporary famine overtakes the colony. In certain species, like the East Indian Œcophylla smaragdina and the South American Camponotus senex, the larvæ are put to a more humane use as spinning machines for constructing the silken nest inhabited by the colony. These examples also illustrate the purposive manner in which an organism can satisfy definite needs by taking advantage of ever-present opportunities and mechanisms.

In the lives of the social insects the threptic, or philoprogenitive instincts are of such transcendent importance that all the other instincts of the species, including, of course, those of alimentation and nest-building, become merely tributary or ancillary. In ants, especially, the instincts relating to the nurture of the young bear the aspect of a dominating obsession. The very strength and scope of these instincts, however, renders the insects more susceptible to the inroads of a host of guests, commensals and parasites. Besides the parasitic larvæ of Chalcidids, Lomechusini and Phorids there are many adult beetles and other insects on which the ants lavish as much or even more attention than they do on their own brood. And when the ants themselves become parasitic on other ants, it is always either for the sake of having their own brood nurtured, as in the temporarily and permanently parasitic forms, or for the purpose of securing the brood of another species, as in the slave-making, or dulotic species.

The philoprogenitive instincts arose and were highly developed among the solitary ancestral insects long before social life made its appearance. In fact, social life is itself merely an extension of these instincts to the adult offspring, and there can be no doubt that once developed it reacted rapidly and powerfully in perfecting these same instincts. It is not so much the fact that all the activities of the social insects converge towards and center in the reproduction of the species, for this is the case with all organisms, as the elaborate living environment developed for the nurture of the young, that gives these insects their unique position among the lower animals. A full analysis of the threptic activities would involve a study of the entire ethology of the social insects and cannot be undertaken at the present time. Nevertheless the bearing of these instincts on the subject of polymorphism can hardly be overestimated and deserves to be emphasized in this connection.

All writers agree in ascribing polymorphism to a physiological division of labor among originally similar organisms. This is tantamount to the assumption that the phylogenetic differentiation of the castes arose in the sphere of function before it manifested itself in structural peculiarities. Although this view implies that the female, or queen, was the source from which both the instincts and structures of the worker were derived, it has been obscured by an improper emphasis on the instincts of the honey-

bee, in which the female is clearly a degenerate organism, and on certain specialized instincts, supposed to belong exclusively to worker ants like those of the slave-makers (Polyergus, and Formica sanguinea). We have therefore to consider, first the instincts of the queen, and second, any evidence that may go to show that instinct-changes precede morphological differentiation in the phylogeny of the species.

It is evident that the social insects may be divided into two groups according to the instinct role of the queen. In one group, embracing the social wasps, bumble-bees, ants and termites, the female is the complete prototype of her sex. Even the queen of the slave-making ants manifests in the founding of her colonies all the threptic instincts once supposed to be the exclusive prerogative of the worker caste. These may be called the primary instincts. After the colony is established, however, and she no longer needs to manifest these instincts, she becomes a mere egg-laying machine and her instincts undergo a corresponding change and may now be designated as secondary. She thus passes through a gamut of instincts successively called into activity by a series of stimuli which in turn arise in a definite order from her changing social environment. The workers, however, are capable of repeating only a portion of the female gamut, the primary series. In gynæcoid individuals there is also a tendency to take up the secondary series, but in most workers this has been suppressed by countless generations of nutricial castration. The social insects of this type may be called **gynæcotelic,** to indicate that the female has preserved intact the full series of sexual attributes inherited from her solitary ancestors. In these the primary and secondary series were simultaneous or overlapped completely, in the gynæcotelic social insects they are extended over a longer period of time and overlap only in part, as social life permits the extension of the secondary long after the primary series has ceased to manifest itself. It will be seen that the division of labor which led to the special differentiation of like females into workers and queens is clearly foreshadowed in the consecutive differentiation of instincts in the individual queen. The second group of social insects is represented by the honey-bees and probably also by the stingless bees (Meliponidæ). In these only the secondary instincts are manifested in the queen, while the worker retains the primary series in full vigor and thus more clearly represents the ancestral female of the species. This type may there-

fore be called **ergatotelic.** The suppression of the primary instincts in the queen honey-bee was undoubtedly brought about by a change in the method of colony formation. When the habit of swarming superseded the establishment of colonies by solitary queens, as still practiced by the gynæcotelic insects, the primary instincts of the female lapsed into abeyance or became latent. This change took place so long ago that it has had time to express itself in the structure of the honey-bee as compared with the worker (shorter tongue and wings, feebler sting, degenerate structure of hind legs, etc.)

The first of the following examples which seem to indicate the occurrence of instinctive prior to morphological differentiation, shows at the same time how the ergatotelic type of the honey-bee may have arisen from the gynæcotelic type of the social wasps and bumble-bees.

1. The queens of certain species of Formica (F. rufa, exsectoides, etc.) are no longer able to establish colonies without the coöperation of workers. The common method of colony formation among these insects is by a process of swarming like that of the honey-bee; a certain portion of the colony emigrates and founds a new nest with one or more of the queens. When this method is impracticable the young queen seeks the assistance of an allied species of Formica (F. fusca), the workers of which are willing to take the place of her own species in rearing her brood. In F. rufa and exsectoides there is nothing in the stature or structure of the queen to indicate the presence of these parasitic instincts, but, in many of the allied species, like F. ciliata, dakotensis, microgyna, etc., the colonies of which are smaller and no longer swarm, or do so only to a very limited extent, the queens have become more dependent on the workers of other species and have developed mimetic characters or a dwarf stature to enable them to enter and exploit the colonies of alien Formicæ.

2. In many ants the callows, or just-hatched workers, confine themselves to caring for the larvæ and pupæ and do not exhibit the foraging instincts till a later period. But even the adult workers may perform a single duty in the colony for long periods of time, if not indefinitely. Thus Lubbock, (1894), and Viehmeyer (1904) have observed in certain Formica colonies that only certain individuals forage for the community. The latter has also noticed that certain individuals, indistinguishable morphologically from their sister workers, stand guard at the nest en-

trances. In other genera, like Camponotus, Atta, Pheidole, etc., with species that have desmergates, the morphological differentiation between foragers and guardians is still unsettled. It becomes completely established, however, in certain genera and species with the suppression of the desmergates. A remarkable example of division of labor without corresponding structural differentiation is seen also in the above mentioned Œcophylla, an ant which inhabits a nest of leaves sewn together with fine silk. According to the observations of Dodd (1902) and Doflein (1905), when the nest is torn apart the monomorphic workers separate into two companies, one of which stations itself on the outside, draws the separated leaves together and holds them in place with the claws and mandibles, while the other moves the spinning larvæ back and forth within the nest till the rent is repaired with silken tissue.

3. An interesting case is presented by the honey-ants (Myrmecocystus melliger and mexicanus.) All the workers of these species, though variable in size, are structurally alike. Among the callows, however, and quite independently of their stature, certain individuals take to storing liquid food, as I have found in my artificial nests of the latter species, and gradually, in the course of a month or six weeks, become repletes, or plerergates. Except for this physiological peculiarity, which slowly takes on a morphological expression, the plerergates and ordinary workers are indistinguishable. We must assume, therefore, that the desire to store food represents an instinct specialization peculiar to a portion of the callow workers. There can be no doubt that as our knowledge of the habits of ants progresses many other cases like the foregoing will be brought to light.

It may be maintained that in these cases physiological states must precede the manifestation of the instincts, and that these states, however inscrutable they may be, are to be conceived as structural differentiations. There is undoubtedly much to justify this point of view. The elaborate sequence of instincts in the queen ant, for example, is accompanied by a series of physiological changes so profound as to be macroscopical. After the loss of her wings, the wing muscles degenerate and the fat-body melts away to furnish nourishment for the ovaries, which, in the old queen, become enormously distended with eggs as the breeding season approaches. Such changes would seem to be amply sufficient to account for the changing instincts. I have found

that mere artificial deälation at once alters the instincts of the queen, probably through a stimulus analogous to that which leads to the atrophy of a muscle when its nerve is severed, and in the case under consideration leads to the degeneration of the wing-muscles and to changes in the ovaries. In the mermithergates and pseudogynes we also have peculiarities of behavior which are attributable to peculiar physiological states. Similarly, nutricial castration may be said to be a physiological state resembling that of hunger. We may conclude, therefore, that the worker, both in its ontogenetic and phylogenetic development, is through and through a hunger-form, inured to protracted fasting. Miss Fielde has shown (1904) that the workers of Camponotus americanus may live nearly nine months without food, which is as long as the much larger and more vigorous queens are known to fast while establishing their colonies. The larvæ of ants, too, are known to remain alive in the nests for months without growing. And even when food is abundant the workers appropriate very little of it to their individual maintenance, but distribute it freely among their sister workers, the brood and queen. It is not improbable, moreover, that the single instinct peculiar to workers, the instinct to leave the nest and forage, is the direct result of a chronic state of hunger.

THE HABITS OF INSECTS AS A FACTOR IN CLASSIFICATION.*

HERBERT OSBORN.

There is, I presume, at the present time a very general agreement among systematists that our systems of classification should represent something more than a convenient placing of groups in divisions in which they may be discovered by some key. Certainly all naturalists who look into the significance of relationship must wish to see their classification represent what they can discover in the way of natural affinity or the lines of derivation of the respective groups. It is also, I presume, a common if not universal experience that in every piece of systematic work there remains at the end some unsolved problem or some remnant of uncertain species that cannot be placed to the satisfaction of the worker. It is not my expectation that I can solve these perplexities in a short discussion of the criteria for taxonomic work, but it appears to me that we may secure some assistance and reach, perhaps, more satisfactory results if we bring to our assistance in this difficult field as many as possible of the factors which have been concerned in the differentiation of species, and, therefore, a recognition of the characters by which species and the larger taxonomic groups may be separated. Of these different factors the habits associated with the life of insects is one which should doubtless be given much greater attention than has been our practice in most of our systematic work. In large part, of course, this is due to the fact that we have been compelled to work with collected material of which we knew practically nothing as to environment or habit, or sometimes, even as to the more general ecologic conditions. Such data ought to be considered more and more an essential part of the basis of classification.

Insects doubtless serve as well as any of the great groups of animals for the illustration of any biological principle, and it is my belief that almost every important principle in biology may be studied and elucidated within the group. What is said here about insects may, therefore, in large part be applied to other

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groups of animals, but I wish especially to speak of this group. No better audience for such a subject could be possible than one including so many who are devoting a large amount of valuable time and effort to the perplexing problems of insect classification.

Some twenty years ago our worthy president, Professor Comstock, published a remarkably suggestive paper on Evolution and Taxonomy in which he set forth in a masterly manner the idea that what we believe in evolution should be used as a basis in our taxonomic work, or that our systems of classification should show the lines of evolution of the various groups. Since then some papers have made good use of this general principle, but there are still many groups in which current classifications have largely ignored the principle or sadly distorted it in interpretation.

Perhaps if we agree on the principle we have used unfortunate methods in determining its application, and it is with the hope of showing possibly a little more clearly one of the helps in determining this point that I propose to discuss the habits of insects in connection with the possible aid they may give us in tracing the lines of evolution.

Primitive insects which we may conceive to have been largely terrestrial in habit have diverged along certain main pathways such as adaptation to aquatic life, underground existence, arboreal life, sedentary condition, parasitic habit, gall making habit, and a host of minor lines of special adaptation. To bring out their significance we may best review somewhat hurriedly some of these lines of divergence.

SUBTERRANEAN LIFE.

The tendency of insects to burrow underground is perhaps one of the more primitive lines of adaptation, as it may very easily be seen to come from their efforts at concealment, to escape enemies, to avoid light, or in arid regions to escape excessive heat, and in many groups as the simplest mode of pupation. From the more general form, however, we find in almost every order cases of especially adapted species or sometimes whole genera or families including varying degrees of adaptation to underground life. Mole crickets are the most perfectly adapted of the Orthoptera, but indications of the easy stages in this group are shown by crickets and stone crickets which are less perfectly fitted for such life. A group taking these features into account would evidently place the mole cricket as the extreme form in this line of adaptation.

Among Hemiptera we have numerous cases of subterranean adaptation, the most of the Cicadas, the root inhabiting Fulgoridæ, Cercopidæ, Membracidæ, and the highly specialized underground species of Aphids and the burrowing Cydnidæ showing a drift in this direction. The Cicadidæ are extremely specialized for such life, and the nymphal stages profoundly modified, showing a long ancestry of underground life. Among the Fulgorids, Membracids and the Cercopids it occurs in isolated forms and in these is in most cases of recent origin. Among the Aphids many species of Rhizobius, Pemphigus and Schizoneura show this adaptation, often greatly complicated with association with ants and by alternation of food plants or different root and leaf feeding forms. In every case, however, there is the best of evidence of the derivation of these root living forms from an ancestry that lived only above ground, and hence a clue to their systematic relationships is easily found.

The ant lion is a special case of adjustment and a striking contrast to the aquatic and terrestrial members of its order. In the construction of its pit-falls it shows a plan of underground life that differs strikingly from that of any other insect and is so distinct that it may be considered a good family character.

In Coleoptera the underground habit is distributed among many different families, but is especially characteristic of the Scarabæidæ in a large section of which the underground condition prevails for all but a short period of adult life. Here there is a very distinct and extreme adaptation both in the matter of food and adjustment to soil that fits them for this condition. Among the flies we have the burrowing larvæ of the crane flies and the Bibionidæ.

Among the butterflies and moths we have but little adaptation to underground life aside from the burrowing into the ground for the purpose of pupation, but cut worms and sod worms spend a considerable portion of their larval life in the soil, though feeding for the most part above ground. The bees, ants and wasps present us with a number of extreme forms of underground habit, but this is in many cases associated with community life. In fact community life seems very likely to have originated in nearly every case from the insects which had adapted themselves to this sort of existence. Some sort of protection such as cavities in the ground or in rocks or trees may have been an essential factor in the development of community life.

ADAPTATION TO AQUATIC LIFE.

The insects which live in the water show very distinct lines of divergence from the terrestrial habit and we can trace in a great many different groups the connection with the land inhabiting forms with very great certainty.

There is at present probably no question as to the general principle of the derivation of aquatic forms from those inhabiting the land, but the relations of the different groups and the particular lines of adaptation are open to further study. One feature that is perhaps sometimes overlooked is that the groups in which the aquatic habit is most perfectly established are those which have been for the longest time fitted for such existence, and therefore show less perfectly the connection with land inhabiting forms. The groups of dragon flies and May flies may both be looked upon as having established the aquatic habit at a very remote period, and as showing at present a very perfect adjustment in the larval stage for this mode of life. In both of these groups the larvæ are capable of aquatic respiration and have been provided with tracheal gills, adapted on different lines, so that they need not come to the surface in order to gain air. The development of these tracheal gills, however, must have been a matter of long evolution, but the fact that they are associated with a complete but modified tracheal system is evidence of their origin, subsequent to that of trachea.

In the mosquito, on the other hand, we have forms in which such a perfect aquatic respiration is not developed, the larvæ, in nearly all species, being obliged to make frequent trips to the surface of the water in order to acquire fresh supplies of air. And here, too, there is a distinct interchange of the contents of the tracheal tubes permitted by the open spiracles. A more specialized condition is shown in the buffalo gnats where there is a development of gill filaments capable of absorbing oxygen from the water and permitting strictly aquatic respiration without any recourse to the atmosphere. It has lately been shown, however, that tracheal tubes are present but become much reduced in these gill filaments so that there is every reason to assume that the aquatic respiration is of comparatively recent origin.

In the aquatic Hemiptera we have a series of families which show successive stages of adaptation to aquatic life, and we may trace by easy stages the passage from land or shore living forms to those which are most completely specialized for aquatic life.

The water striders which live entirely on the surface of the water have a rather special adaptation, but with the Naucoridæ we reach a group in which the aquatic life is well established. These insects have their form well fitted for swimming, but their respiration is dependent upon the atmosphere, and they must make frequent trips to the surface. Somewhat more specialized are the Belostomidæ in which the ability to remain under water is very perfectly developed, but without special gill structures for aquatic respiration. The Nepidæ go further in that they have long tubular structures which permit them to reach the surface of the water without bringing the body up to the surface. The water boatman and Corixa, though not more specialized in these features, show in some other respects a more perfect adaptation and are to be considered as among the most extreme of the aquatic groups. It seems to me apparent from such a series as this that the arrangement of groups should be made to correspond as closely as possible with the successive stages in specialization for the particular habitat which is present. That these insects are descended from strictly terrestrial forms seems certain, and that their various adaptations represent different degrees of perfection in adjustment to the new habitat will, I believe, fit in most perfectly with the comparative study of their structure. It is shown, perhaps, most decidedly in the condition of the antennæ and in the modifications of the legs in adaptation to swimming.

Most of the aquatic beetles appear to have but recent adaptation to this habit, as all are obliged to secure air from above water, and in most species a considerable ability to live outside the water is present. It is also quite certain that the aquatic habit has in this group been acquired independently in the different families.

With the evidence that may be accumulated in all the different orders of insects it seems certain that in every group of insects having aquatic habits we may confidently trace a derivation from terrestrial ancestors, and hence in arranging phylogenies we may consider that those less perfectly adapted are the more primitive and those most perfectly fitted for aquatic life are the most specialized. This will involve some radical changes from accepted and time honored systems of classification, but will, I believe, in every instance result in more rational and satisfactory groupings.

THE SEDENTARY HABIT.

Insects in many different groups show a tendency to become fixed for part or all of the life cycle, and in some cases they reach very extreme conditions in this direction. It is most pronounced in the group of Hemiptera, and in this group it shows a very complete series of gradations from the free forms to those which are most extremely sedentary. In the Psyllidæ for example there are some forms which show a tendency toward attachment during the larval stages, but in others this is modified into the gall infesting habit. In the white flies there is fixation during the larval and pupal stages with the free adult. In Aphids there are many species which attach themselves by the mouth parts and remain practically fixed for long periods. This is notably true of such species as the beechblight, alderblight, wooly aphis and others. Among the scale insects we have the most extreme condition, but there are gradations from such free forms as the mealy bugs and the Orthezias through the unarmored scales to such very extreme forms as the Diaspids. There can be no question, it seems to me, that these series show the lines of divergence and that the more extreme attached species must have descended from those which had greater freedom, and that the sedentary habit has in this group become more and more fixed.

Some of the moths show a considerable tendency to fixation, and examples such as the case bearers and bag worms and the tussock moths show steps in the direction of fixation for certain portions of their existence.

COMMUNITY LIFE.

The community life in insects is another very striking line of adaptation and one in which we can see most positively the gradual derivation from the more primitive forms in which communal life is unknown. In its simplest condition it may be considered as represented in the aggregation of larvæ which remain and feed together for a considerable period, but in which there is nothing more than a mutual protection, construction of tents or other devices, and no development of distinct kinds of individuals as a result of social habit. We have, however, amongst the termites, the ants and the bees, extreme cases where the community habit resulted in a very striking production of different kinds of individuals in a colony, these being adapted to carrying on entirely different activities. While termites, ants and bees must be con-

sidered as having acquired the community habit independently, they have very distinct parallelism in the kinds of individuals which are produced. In all cases there are normal males and females and also a class of non-sexual individuals or neuters, but in both termites and ants these neuters have been further differentiated into forms which carry on different kinds of activities in the colony, as for instance workers and the soldiers. In some ants these duties are still further subdivided and give rise to most perplexing series of polymorphic forms.

Those of us who had the opportunity to hear Professor Wheeler's brilliant address a year ago will remember how remarkably these polymorphic forms have been developed and can appreciate also how essential a recognition of the functions and the lines of adaptation for these forms must be, in order that anything like rational arrangement of the species may be made.

Community life in birds, beaver, fur-seal, sheep, cattle and even in the human species has not by any means the extreme condition of specialization seen in some species of these insects that have been mentioned. Nowhere does it show anything like so profound a change in the economy, structure or the relations of the members in the community.

PROTECTIVE DEVICES.

In the way of special adaptation for protection, insects show a wonderful variety of forms and have been one of the favored groups for the illustration of this general practice in nature. We can illustrate it by the use of certain forms among our common species such as the gypsy moth which with its color and marking has become very perfectly adapted for protection on the bark of the birch which appears to have been its native food plant, as shown by Prof. C. H. Fernald at the Boston meeting. Our common luna moth probably illustrates this also, since its coloration is well adapted for protecting it among the leaves of its most common food plant. It appears also that the long tail of the hind wings may very likely assume the position of the petiole of the leaf, and therefore fit in very perfectly with the surroundings of the insect. I have been struck by this particular feature in seeing the moth resting in such a position as to simulate closely an attached leaf. Among the leaf hoppers there are a number of species which show a very complete adaptation in this direction. Nearly all of the species of Deltocephalus if noticed

in connection with the plants on which they are feeding will be found to have, both in color and shape, a most perfect protection in connection with the plants on which they are attached. In the little Lonatura there is not only a distinct similarity in the size and color of the small stems of its host plant, but there are short winged forms which fit in at certain seasons of the year still more perfectly with the food plant or the debris on the surface of the ground in which they may be collected. Driatura in the long and short winged forms appears at first sight to be rather conspicuous, but if taken in connection with the places where it lives is found to blend most perfectly with its surroundings and to be thereby very perfectly protected. Perhaps the most striking example among our native species is to be found in the genus Dorycephalus which lives upon the stems of large grasses, and in this form the head is very much elongated, the wings shortened, and the color so perfectly straw-like that upon the stem of the plant the insect becomes entirely invisible. The males are dark in color with longer wings, and probably rest more continuously on the darker portions of the dried leaves. A still further adaptation occurs with the young which collect in the heads of the plant and which resemble most perfectly the glumes of the seeds. So perfect is the adaptation in this form that none of the stages are readily found and it is only by beating the plants that they may be collected. A related species (D. vanduzei) occurring on smaller stemmed plants is perhaps even more distinctly specialized, the wings being more reduced and the body more elongate.

Another case which is especially striking is found in a small capsid which lives at the surface of the ground and which in the female is entirely wingless and the body so modified as to very perfectly resemble an ant. This resemblance does not stop with a superficial similarity, but may be noticed even in the basal segments of the abdomen which simulate in a striking manner the same segments in the abdomen of the ant. The male of this species is longed winged, very strikingly different from the female, and doubtless lives under quite different conditions, making use of its wings and flying readily from place to place.

Another quite striking case is to be found in the beach grasshopper which is common to sand dunes and beaches throughout a quite extended range of the United States. This species shows most perfect adaptation for protection on the surface of the sand, the spots and marking on the body blending so perfectly with the

color and form of sand grains that when at rest it is quite invisible. In the photograph shown the outline is indicated by shadows which were really necessary in order to make it apparent, but it may easily be seen, that without these it would be extremely difficult to discover the insect. Now none of these adaptations can be thought of as primitive but rather as highly specialized forms derived from an ancestry of more general habit. Ought this not to be recognized in their classification?

GALL MAKING INSECTS.

Another quite distinct line of divergence for insects is found in the gall making habit, a habit which involves not simply the action of the insect, but the stimulation by the insect of a certain plant activity that results in an abnormal growth which is of service to the insect either as a source of food material, or for protection, or both. That this adaptation occurs independently in many different groups of insects is clearly evident if we consider the distribution of the gall making groups. It is present even in the Acarina, species of which produce a very great variety of galls on many different plants. Among the true insects the aphides contain a considerable number of gall making species, and in some of these the galls are quite elaborate in structure. The Pemphiginae found on elms and poplars show very distinctly formed structures such as the poplar leaf gall. In the genus Phylloxera which is distinctly a gall making genus we have the common grape species and numerous species affecting the hickory, in all of which there is a very distinct gall for each species. The Psyllidae are distinctly gall making and the galls produced are very characteristic, and the whole life of the insect is adapted to this method of existence.

Among the beetles we have a number of gall making species, those of the genus Agrilus perhaps being the most distinctive, but it is evident that the gall making habit in this group is entirely independent of that in any other order, and even of any other family of the group of beetles. In the Diptera several families include gall making species, but the gnats are most distinctly developed in this direction. We have, however, every gradation in this family from species that are not gall makers up to those which produce the most perfect and constant forms, for example, the Hessian fly, willow galls and the grape filbert galls.

Of the Lepidoptera comparatively few gall makers are known, but amongst the tineids we find gradations from miners to gall makers.

Among the sawflies there are several genera which live entirely in galls and here again quite complete gradations may be observed from the more general mode of life to the distinctly gall making form. The most distinctly gall making group, the Cynipids, presents us also with almost every possible gradation from the simple attack on leaves to the formation of very elaborate gall structures, and by careful comparison of different forms we can trace with considerable sureness the lines of divergence for each of the species and their relative departure from primitive forms.

WOOD BORING INSECTS AND BARK BEETLES.

Of the insects that work into the substance of woody plants we have a considerable number, and many of them illustrate a long course of adaptation to this particular form of life. The termites show an extreme ability to tunnel into wood and devour the interior of large masses of woody structures, and for this purpose have the mouth parts considerably specialized. The habit, however, is associated with the community habit which is discussed under another head. Among the Lepidoptera we have several families in which this mode of life has been quite fully developed, the most striking forms being the Cossidæ including the large carpenter moths, the larvæ of which tunnel deeply into various hard wood trees, and the Sesiidæ, practically the entire family being specialized for this habit. It shows, however, considerable degrees of adaptation, the peach borer living mainly just beneath the bark in shallow cavities which may open to the surface, while in the Syringa borer, Currant borer and some others, the central portion of the stem or trunk of the tree is invaded. Among the beetles the family of long horned borers (Cerambycidæ) is among the most characteristic, and excepting a few forms such as the milk weed borers are adapted for penetrating deeply into very hard wood. The Hickory borer for example tunnels into the heart wood of Hickory, requiring a period of two or three years for its growth. The Locust borer, Poplar borer, and the familiar Apple borer are other well known examples. Again in the Buprestidæ we have a distinctly wood boring group, although in these the borers are usually confined to the younger wood or cavities beneath the bark. They show perhaps less

complete specialization for boring, but in the flattened form of young and adult show adaptation to the particular portion of the tree which they affect. The bark beetles present a somewhat different condition, but are no less distinctly specialized for their particular habitat. They live for the most part between the bark and hard wood and construct intricate tunnels sometimes of most peculiar pattern, and frequently occasion very great injury to the trees infested. The habit in these different groups has very evidently been reached by entirely independent routes and the lines of adaptation must be traced in each group separately. Often the particular steps of adaptation are very beautifully shown in the series of species which illustrate the divergence from external leaf eating forms to those which are most perfectly fitted for living within the plants.

Of the Hymentopera the horn-tail borers are the most distinctly specialized in this direction, and these show a derivation from the leaf feeding saw-fly forms. The ants and bees which burrow into wood or into the stems of plants show certain other forms in which the habit has been adopted by isolated small groups, but not adopted by the larger divisions.

THE PARASITIC PATHWAY.

In the direction of parasitic life some groups of insects have traveled very far and show almost as distinctly as any group of animals the effects of the parasitic life. So numerous are the examples in this line that we must select only a few of those which are most specialized or which illustrate most perfectly the lines of derivation for the habit. In the Mallophaga we have a group in which the parasitism is distinct for all the known species and in which the result of parasitism is shown in the entire absence of wings and in the very perfect adaptation of clasping organs in the feet. In their mouth parts and other structure, however, they show very perfectly their derivation from some psocid ancestor, and by selecting series of genera we can trace quite clearly the different steps in adjustment from forms which are but slightly parasitic to those which are most extremely dependent upon their attachment to a host. In some cases migration from one kind of animal to another is possible and probably frequent, but in other species more strikingly specialized there is a most rigid restriction to a single species and absolute dependence upon the association of individuals in that species for its distribution and survival.

The bot flies illustrate remarkably well the degrees of specialization in the parasitic life, the sheep bot which lives in the frontal sinus of the skull representing a much less important departure from a non-parasitic form than the horse bot which lives within the stomach and must be adapted not only to a special mode of nutrition but to a particular limitation in the matter of respiration, a feature which goes still further in the case of the ox bot with its circuitous route from egg through alimentary tract to its final resting place beneath the skin. We cannot conceive this latter form of adaptation except as a derivation from the more simple form of parasitism, and our classification in this group may well take this into consideration. A particularly extreme form of parasitism with the results of parasitic life is exhibited in the sheep tick and its allies where there has been not only a striking modification of the structures of the body, but a profound modification in its mode of development. In this it shows an extremity which is perhaps not exceeded by any other group of animals though paralleled by the parasitic Stylopidæ, and in every detail of which we must recognize the effect of the parasitic life. The other forms of parasitism such as the occupancy of the nest of bees by flies or other species of bees which occur in a bewildering number of intricate forms cannot be dwelt upon here. The remarkable adaptations of such parasitic forms as the Ichneumons and Chalcids in their adjustment to plant lice and scale insects, and the egg parasites in their extreme adjustment to the completion of a life cycle within the minute egg of some other species of insect, cannot fail to occur to all who have become at all familiar with the complexities of insect life.

I may perhaps be permitted to further illustrate this idea with one other example drawn from a group which has been one of my special studies. The Pediculidæ are, I will grant, a not very popular division of insects and yet in some of their adaptations and in the long course of parasitism which they seem to have undergone, they give us some of the most positive evidences as to the effects of the parasitic habit and also as to their course of evolution. We may readily appreciate their long adoption of the parasitic habit when we consider the wide divergence they show from other groups of insects, and the range of their hosts, and yet we must assume beyond question that their establishment as a parasitic group has been subsequent to the evolution of the group of mammals of which they are exclusively parasites.

I have elsewhere indicated my belief that the group originally came from some division of the Heteroptera and I am still skeptical concerning the recent attempts to relate them to Mallophaga, but for the present study this point is not essential. Granted a primitive form assuming the parasitic relation to some primitive mammal and we have the materials on which to construct a tentative phylogeny which we may test by such evidences from morphology, distribution and habit as may be available.

There are of course at least two plans on which we may account for the present distribution of the species of this family. One that the primitive parasitic form appeared at some time in the early history of the mammalian stem and that its subsequent history and the divergence of the various species has gone along parallel with the divergence of the host forms; the other that it appeared much later in history after the establishment of the mammalian groups and that from an establishment on some one group of animals it migrated to other mammals and the various species developed on new hosts by more recent evolution. The fact that most of the species have a single host to which they are restricted gives unusual opportunity to test any theory of evolution.

Confining ourselves to the Pediculidæ, although it would be interesting also to examine the relation of the Polyctenidæ occurring on bats, we have a group showing very clearly a common origin and possessing some very homogeneous characters, the most evident the single jointed rostrum and the single clawed tarsi. The separation of the genera has always seemed somewhat arbitrary and based as a matter of necessity in such simple forms on rather trivial characters, but some of these characters take on entirely new significance if correlated with the distribution of the genera with reference to their hosts.

It will be noticed from the diagram (Pl. II) that the groupings of these parasites bear a distinct relation to the main divisions of the class of Mammalia. While this is not presented as an accurate statement of the phylogeny of the mammals, nevertheless it represents the remoteness of some of these groups and illustrates something of the possible relationships between them. Assuming that the primitive parasitic group established itself on a primitive mammal, we can follow the divergence of the different groups with considerable assurance. There is a distinct type belonging to the group of rodents, another for the insectivora, another for

the ungulates, still another for the elephant, and a group covering the primates. Comparing these it appears that the ungulate and primate groups have really a closer relationship than either of these with the rodent forms, although in existing classifications the ungulate and rodent forms are embraced within the same genus. It appears to me more in accord with the facts, especially if we take into account this distribution and habit, to separate the rodent forms, and this will necessitate the forming of a new genus.

Clasping organs show distinct types for a number of these groups and quite varied forms in such apparently nearly related species as those affecting Horses, Hogs, Cattle, etc. The Insectivore type is extreme and introduces new features.

We have traced a few of the many lines of adaptation that have been followed by the groups of insects in their adjustment to the many and varied conditions of life; adjustments so numerous and so perfect that insects are today not only the most numerous in species but fitted to a greater range of conditions than any other class of animals. We certainly should take account of these different conditions in our systems of classification if we hope to have them represent the true relationships in nature. We should use the lines of divergence in habit to point the way to natural affinities. Distinct morphologic changes are almost invariably associated with adaptations, if indeed, they are not the direct response to these adaptations, and hence when habit, distribution, function and structure are read together, we should, if reading correctly most nearly approach the rational arrangement of groups.

I would not be understood as ignoring the fact that this principle has been recognized in the past. Such names as Phytophaga and Parasitica in Hymenoptera, Phytophaga, Mycetophaga, Hydrophilus, Gyrinus, Cryptophagus, etc., in Coleoptera, or such specific names as aquaticus, arborea, sub-terraneus, cavicola, etc., testify to due appreciation of habits by many systematic workers. But I wish to emphasize my belief that this principle may be used to advantage not only in tracing larger phylogenetic lines but in solving the perplexities of specific affinities among the minor taxonomic groups.

Students of animal behavior and psychology are beginning to associate the differentiation of groups with psychic characters, and such a claim as physiological species is not new even to ento-

mologists. It is evident that if systematists would keep their field of work abreast with the movements in other lines it will be necessary to take into account all the factors that may seem to give evidence as to affinity.

It should be clearly appreciated, however, and I think will be recognized by entomologists as quickly as any body of naturalists that habit is only one factor, that while it has had a determining influence in producing structure it has so frequently occurred in parallel lines in different groups that fundamental structures based doubtless on the more remote habit, must be taken into account. To ignore this would carry us back to such inconsistencies as placing whales with fishes, or the parasitic insects, fleas, lice, bird-lice, etc., in one group, Aptera. We must fully determine the significance of the deeper adaptations as revealed in more fundamental character along with the superficial modifications of more recent habit.

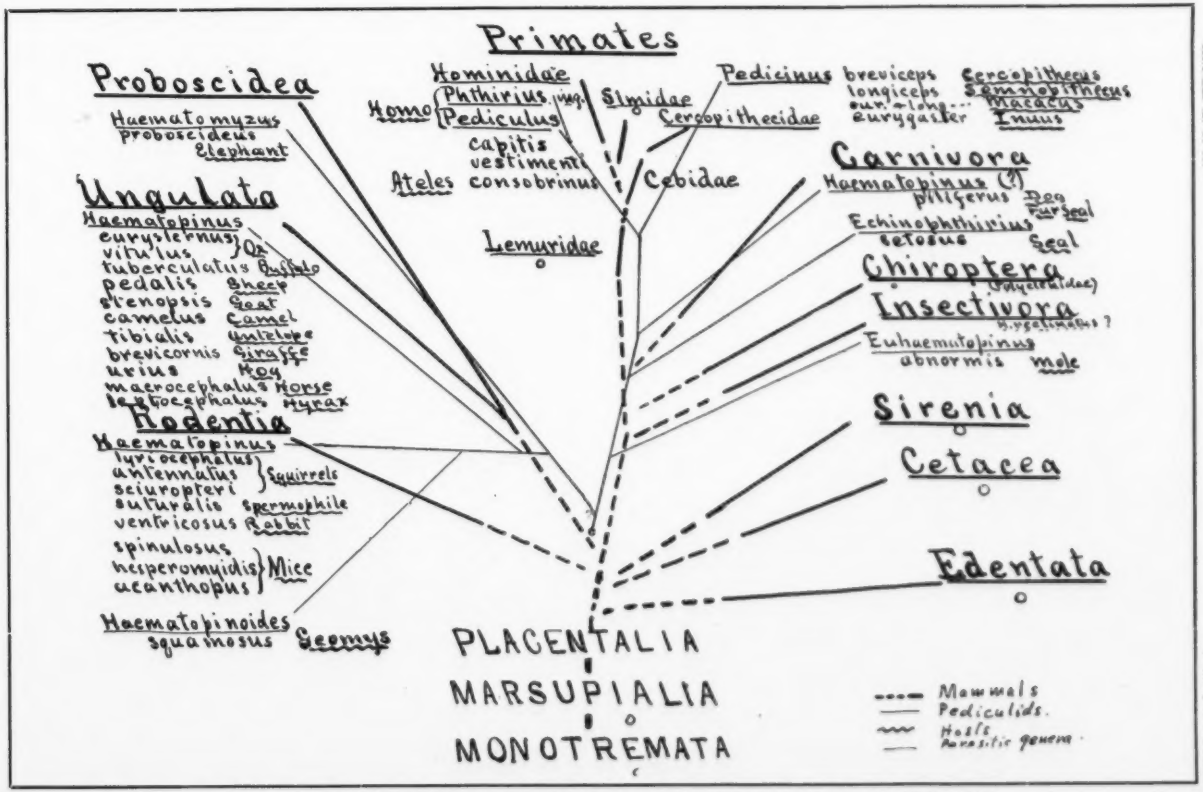

DIAGRAM ILLUSTRATING POSSIBLE LINES OF DIVERGENCE IN PHYLOGENY OF PEDICULIDAE.